Adult Chinook Escapement Assessment Conducted on the Cowichan River During 2002

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Nanaimo, British Columbia
V9T 6N7

2004

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2655

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Cat. No. Fs 97-4/2655E ISSN 0706-6473

Correct citation for this publication:

Nagtegaal, D.A., E.W. Carter, N.K. Hop Wo, and K.E. Jones. 2004. Adult chinook escapement assessment conducted on the Cowichan River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2655: 49 p.

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ABSTRACT

Nagtegaal, D.A., E.W. Carter, N.K. Hop Wo, and K.E. Jones. 2004. Adult chinook escapement assessment conducted on the Cowichan River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2655: 49 p.

In 2002, the Biological Sciences Branch, Pacific Biological Station, continued a study of chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. This in-depth escapement assessment project has been in place since 1988. Major components of this study included: i) enumerating spawners and total return, ii) estimating First Nations food fish catch, iii) recording hatchery broodstock removals, and iv) collecting biological, environmental and coded-wire tag data. Population estimates for adult and jack chinook were determined based on the fence count since this was considered to be the most accurate enumeration method. A carcass mark-recapture study was conducted on the spawning grounds to augment the collection of biological data and to supplement the fence count population estimate. The total return of adult chinook to the Cowichan River was estimated to be 5,785 fish of which 2,505 spawned naturally in the river. A total of 1,480 adult chinook were collected for hatchery broodstock, 1,500 adults were estimated as captured in the First Nations food fishery and approximately 300 adults were lost to seal predation.

RÉSUMÉ

Nagtegaal, D.A., E.W. Carter, N.K. Hop Wo, and K.E. Jones. 2004. Adult chinook escapement assessment conducted on the Cowichan River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2655: 49 p.

En 2002, la Direction des sciences biologiques de la Station biologique du Pacifique a poursuivi dans la rivière Cowichan l'étude sur la productivité du saumon quinnat (Oncorhynchus tshawytscha), un projet d'évaluation approfondie de l'échappée, lancée en 1988. Cette étude comporte les principaux éléments suivants : i) dénombrement des géniteurs et de la remonte totale, ii) estimation du volume des prises autochtones à des fins alimentaires; iii) consignation des prélèvements de géniteurs d'élevage et iv) collecte de données biologiques et environnementales et de données de micromarques magnétisées codées. Les effectifs de quinnats adultes et unibermarins sont estimés à partir des données de barrière de dénombrement étant donné que cette méthode de dénombrement est considérée comme étant la plus précise. Des carcasses de saumons étiquetés sont récupérés dans les frayères de sorte à enrichir les données biologiques et améliorer l'estimation des effectifs fondée sur les données de barrière de dénombrement. La remonte totale de quinnats adultes dans la Cowichan en 2002 a été estimée comme se chiffrant à 5 785 poissons, dont 2 505 ont frayé naturellement dans la rivière. Un total de 1 480 géniteurs ont été prélevés aux fins d'élevage et, d'après les estimations, 1 500 adultes ont été capturés dans le cadre de la pêche autochtone à des fins alimentaires et 300 autres ont été la proie des phoques.

INTRODUCTION

Chinook stocks are invaluable to both commercial and recreational fisheries of the Pacific Northwest (Collicut and Shardlow 1995). In spite of protective measures, chinook salmon abundance has continued to decline. This trend has resulted in the recent addition of chinook to the list of threatened and endangered species in the United States (Waples 1991). The problem of declining stocks is similarly serious on the West Coast of Canada, and has potential ramifications regarding the sustainability of British Columbia's fishing industry (Argue et al. 1983). Over the past several years, considerable interest has been focused on the chinook stocks of the southern portion of the Strait of Georgia due to the decline in these stocks and their importance to local fisheries (Farlinger et al. 1990). The Stock Assessment Division, Pacific Biological Station, initiated a study of chinook productivity to assess rebuilding strategies and to evaluate the effects of harvest management policies for these stocks. In the fall of 1988, a study was implemented on Cowichan River chinook with additional information collected from the Squamish and Nanaimo River stocks. These three stocks within the framework of the Pacific Salmon Treaty between Canada and the United States were identified as exploitation and escapement indicators and deemed to represent the status of all lower Georgia Strait chinook stocks (PSC 1990). Since then, due to logistical reasons the Squamish River system was dropped as an indicator, and in 2002 the Nanaimo River system was dropped as well.

Major hatchery production of chinook on the Cowichan River began in 1980 (Cross et al. 1991). Chinook fry releases have increased from 64,681 in 1980 to 3.23 million in 2002. Coded-wire tag (CWT) releases also began in 1980 and by 2002 approximately 7% of the chinook released carried coded-wire tags.

This report presents the results of the study completed during 2002. The objectives included:

1. enumerating chinook, coho and chum salmon migrating past the counting fence,
2. estimating First Nations food fishery catch,
3. recording hatchery broodstock removals,
4. collecting biological data and sampling coded-wire tag recoveries,
5. implementing a carcass mark-recapture study for both adult and jack chinook, and
6. monitoring results of the Cowichan River Water Management Plan.

METHODOLOGY

A detailed description of the methodology is presented in Nagtegaal et al. (1994b). A summary of the methods is presented below along with any changes that were incorporated during the 2002 study.

STUDY AREA

The Cowichan River watershed is located on the Southeast coast of Vancouver Island and drains an area totalling 826 km^2. The Cowichan River system includes Cowichan, Bear, Mesachie, Somenos, and Quamichan lakes. Cowichan Lake (62 km^2), the largest of the five lakes, is situated approximately 50 km west of the Cowichan Bay estuary. Discharge from a flow control dam situated at the outlet of Cowichan Lake ranges from 7 to 326 m^3/s, and averages 44.9 m^3/s (Feilden and Holtby 1987). A total of 26 tributaries drain into the Cowichan River. The largest of these is the Koksilah River, which intersects the mainstem of the Cowichan River approximately 2.5 km upstream of the estuary. The Cowichan River watershed system is a typical Vancouver Island and coastal British Columbia stream in which maximum flows occur during winter months due to heavy rainfall (McDougall 1985).

The Cowichan River supports many salmonid species including chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), chum (*Oncorhynchus keta*), sockeye (*Oncorhynchus nerka*), and pink (*Oncorhynchus gorbuscha*) salmon; as well as cutthroat trout (*Oncorhynchus clarki*), steelhead trout (*Oncorhynchus mykiss*), kokanee salmon (*Oncorhynchus nerka*), and dolly varden char (*Salvelinus malma*). Attempts have been made to introduce several other species including: atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*) (Perrin et al. 1988). The salmonids of the Cowichan River support several vital fisheries, which include a First Nations food fishery, tidal sport fishery, and a commercial ocean fishery.

ENUMERATION FENCE

The counting fence was placed upstream of the city of Duncan, in the same location as in previous years (Figure 1). The design incorporated a resistance board weir with a counting raceway (adjustable flashboard) and trap box adjacent to a counting tower equipped with floodlights. Counts were continuously recorded by 15-minute interval for adult and jack chinook, adult and jack coho, and chum salmon. If identification was in doubt, fish were recorded as unknown. Water depth, temperature, water clarity, and weather condition were recorded three times per day. The fence was checked daily for any breaches and cleaned of leaves and other debris. Any removal of broodstock at the fence site by hatchery staff was recorded.

Fence Enumeration Video

An underwater video camera was installed at the fence site in order to verify and provide an independent record of fish passing through the enumeration fence. Fish were recorded by species, with chinook sex and adipose fin status also being noted. Morphological features were used to help identify jack chinook from adult chinook.

SWIM SURVEYS

In an effort to maintain consistency with historical data sets, swim surveys were conducted, in conjunction with Cowichan Tribes Aboriginal Fisheries Management (CTAF), to estimate the spawning population of chinook. Swims were made in the upper section of the river only (Figure 1) with counts extrapolated to the total system. Each survey was conducted by three experienced swimmers while one person in a canoe recorded the data. Each swimmer (one in the middle and one on each side of the river) counted the fish seen within their range of visibility. The three swimmers attempted to keep abreast as they approached each pool while the person in the canoe lagged behind within hailing distance. Counts were recorded by pool/riffle and then compiled by river section. To maintain consistency in counting procedures the same swim team was used for each survey whenever possible. Based on the historical distribution of spawners, swim counts were expanded by a factor of 3.4 to derive an estimate of total escapement (Nagtegaal et al. 1994a). This expansion factor was consistently applied to swim counts with no adjustments made for run timing or changes to spawner distribution. A final escapement estimate was then determined based on consultation with Fishery Officers using the swim counts in conjunction with other anecdotal information.

It was intended that the swim survey estimates remain independent of the fence count. However, even though fence counts were not passed on to the swim teams during the season, general trends in escapement numbers were known.

FIRST NATIONS FOOD FISHERY

In 1990, a systematic approach was developed by the Cowichan Tribes Aboriginal Fisheries Management program to monitor the fishery more closely and to better estimate the First Nations food fish catch (Paige 1992, 1997). This approach involved recording catch and effort by management zone within the First Nations fishing boundaries (Figure 2). A crew of four observers patrolled the fishery on a daily basis and interviewed fishermen for numbers caught by area and total time spent fishing. In this way, weekly estimates of catch per unit effort (CPUE) were obtained. CPUE was adjusted for daily changes in fishing effort and differences in effort among fishing zones. These data were then extrapolated over time and area to estimate total catch by week and summed over all weeks to estimate the total catch for 2002.

$$CATCH \equiv \sum_{n}^{w=1} CPUE_{w} \times EFFORT_{d}$$

where w refers to the time interval for catch (week), and d refers to the time interval for effort (day). No confidence limits were calculated (Paige 1997).

For some years since 1988, an observer was employed to independently collect catch and biological data from the in-river First Nations fishery. Due to budget constraints no observers were employed from 1999-2001 and CTAF catch estimates could not be independently verified. However, in 2002 an independent observer was in place to enumerate the in-river First Nations fishing catches.

BIOLOGICAL DATA

Biological data for chinook were collected from hatchery broodstock samples and from carcasses recovered on the spawning grounds. Data collected included sex, post orbital-hypural (POH) length, and adipose fin status (present/absent). All chinook sampled from either the spawning grounds or hatchery broodstock were examined for the presence of a CWT using either a Northwest Marine Technology[1] Handheld Wand Detector or a Northwest Marine Technology[1] R9500 Tunnel Detector. All adipose fin clipped chinook and fish suspected of having a CWT had heads removed for decoding of coded-wire tags as well as scales obtained for age analysis. All chinook recovered on the spawning grounds were sampled and spawning condition was noted. Hatchery staff randomly collected biological data from approximately 25% of the chinook broodstock and from all chinook suspected of carrying a CWT.

MARK-RECAPTURE

A mark-recapture program involving the tagging and subsequent recovery of chinook jack and adult carcasses was conducted on the spawning grounds. Crews consisting of two or three individuals surveyed the upper section of the river each day using an inflatable boat (Figure 1). All chinook carcasses encountered were individually tagged with a Ketchum[2] aluminum sheep ear tag on the left operculum and immediately released in the same area as captured. Location of capture and release, tag number, spawning condition, POH length, sex, and adipose fin status (present or absent) were recorded for each carcass. Tag number and recovery location were recorded for all previously marked carcasses, which were then removed from the system.

The section of the river selected for the mark-recapture study is located above Skutz Falls and represents the area where the majority of chinook spawning has typically occurred. A 4.2 m pole with a gaff hook attached to the end was used to recover carcasses. Carcasses that ended up in deep pools were occasionally unable to be retrieved.

Mark-recapture estimates were generated using the Petersen model (Chapman modification) stratified by sex (Ricker 1975). Data were stratified to minimize the effects of differential tagging and tag recovery between sexes. This study follows the estimation procedure as outlined in previous reports (Nagtegaal et al. 1994a, 1994b, 1994c).

To determine the validity of the mark-recapture estimate, potential biases were assessed to test for violations of the assumptions inherent in the Petersen mark-recapture method (Ricker 1975; Seber 1982; Krebs 1989). Sex related bias in the application sample was examined by comparing the sex ratio of the marked versus the unmarked recoveries. Sex related bias in the recovery sample was assessed by comparing the sex ratio of recovered samples with unrecovered samples. Size bias in the application sample was examined by comparing lengths of marked versus unmarked recoveries. Size bias in the recovery sample was examined by comparing lengths of recovered and unrecovered tag samples. Statistical comparisons of length data were carried out using pooled variance Student's t-tests. Temporal bias in application samples was

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[1] Northwest Marine Technology Inc., Shaw Island, Washington, U.S.A.
[2] Ketchum Manufacturing Ltd., Ottawa, Canada.

assessed by stratifying sampling dates into approximately equal periods and comparing mark incidence among strata. Similarly, temporal bias in recovery samples was stratified by dates and the ratio of tagged recoveries to tags applied was compared. Statistical assessments of sex and period biases were carried out using Chi-square tests.

WATER MANAGEMENT PLAN

Low flow and low water levels likely result in delayed fish movement and higher water temperatures which may potentially increase levels of diseases and parasites. During particularly low water levels the river flow can be increased with a controlled water release from the Lake Cowichan Weir. Discussions between NorskeCanada, Fisheries and Oceans Canada, Land and Water British Columbia, Cowichan River Hatchery, Cowichan Tribes and other user groups lead to a water management plan for the Cowichan River. This plan was committed to maintaining Cowichan River water levels for fish, First Nations and recreational users.

POPULATION ESTIMATE

Chinook population estimates are based on fence data when enumeration conditions are good and when counts are deemed reliable. Before a final estimate is reached fence count data are adjusted by jack/adult ratios observed from spawning ground chinook recoveries and expanded by a further a 15% to account for chinook arriving prior to installation and after fence removal. Total run size is calculated by using adjusted fence count data, First Nations food fishery removals, hatchery broodstock removals and seal predation estimates. The mark-recapture estimate is used in years when fence count data are unreliable.

RESULTS

ENUMERATION FENCE

The enumeration fence was installed upstream from the City of Duncan at the traditional site (Figure 1) and was operational from September 3 to November 13. Water conditions were clear for most of the study with only four days noted as cloudy and four days as partially cloudy (Table 1). As a result, conditions were ideal for viewing fish migration past the counting tower and all counts are deemed to be reliable. A total of 2,745 chinook adults, 1,667 chinook jacks, 3,807 coho adults and 602 coho jacks were counted migrating past the enumeration fence. In addition, 79,952 chum and 160 unidentified fish were enumerated at the fence site (Table 1). Since there were no breaches of the fence during the project it was assumed that all fish migrating past the fence during the study period were enumerated.

In past years, chinook jacks have been prominent during the early segment of the return migration often matching adult chinook counts. In 2002, the proportion of jack chinook mirrored the overall temporal pattern of adult chinook migration past the fence (Table 1, Figures 3a, 3b).

The pattern of daily migration past the fence was examined by summarizing hourly counts throughout the program (Table 2). A major peak in migration for both adult and jack chinook occurred between 0600 and 1000 hrs. During this period, 33.4% of adult chinook and 30.3% of jack chinook moved past the fence site.

In past years, tower counts and species identification were verified on several occasions throughout the run by capturing all fish migrating past the fence during one counting segment in the upstream trap box. With the addition of video monitoring, this practise was not carried out in 2002.

Video Enumeration Data

During the 2002 chinook assessment over 130 hours of fence enumeration video was recorded. Fence video was recorded between 11 September and 08 November during various time intervals ranging from one hour to 4.5 hour segments. Video data were recorded by species with chinook being differentiated by sex as well as adipose fin clip status. Video data were used in comparing species identification, jack/adult ratios and adipose clipped mark rates with fence enumeration data as well as with mark-recapture results. There were 35 corresponding time periods between video data and fence data from which species and jack/adult comparisons could be made.

During corresponding time periods, video data enumerated 4.3% more fish and 4.8% less chinook than were recorded at the enumeration fence. Of the 829 chinook identified by video analysis during this period, 395 were adult, 134 were jack and 297 were unknown sex chinook. Fence observer data from corresponding periods yielded 868 chinook of which 523 were adult and 345 were jack chinook. Video analysis identified 74.7% of chinook as adults compared with 60.3% from fence records. Video data also provided chinook mark rates with 3.8% of male chinook, 5.5% of female chinook and 1.0% of jack chinook missing adipose fins.

SWIM SURVEYS

A summary of all visual surveys conducted by DFO Fishery Officers and by the Cowichan Tribes Aboriginal Fisheries Management group from 1981 to 2002 is presented in Table 3. Total escapement estimates for each year include adult chinook only. In 2002, only one swim survey was conducted on October 23 in the upper section of the river between Road Pool and Train Trestle (Figure 1). The survey was completed during low river flow and good visibility. Adult chinook counts were 418 and this number was expanded to an estimate of 1,421 fish.

FIRST NATIONS FOOD FISHERY

Historical estimates of the number of chinook captured in the in-river First Nations food fishery are presented in Table 4 and Figure 4. The 2002 catch estimate of 1,500 adults and zero jacks was determined by the Cowichan Tribes Aboriginal Fisheries Management group (Figure

2). An independent DFO fisheries observer estimated First Nations food fishery catches of approximately 1,700 adult chinook. Also, if non-catch mortalities (fish that escaped capture but died before spawning due to fishery induced injuries) were included, the impact of the fishery would likely be more significant.

HATCHERY COMPONENT

Between September 23 and October 21, Cowichan River Hatchery staff collected 636 male and 622 female chinook from the river downstream of the fence. In addition, 86 male and 136 female chinook were collected upstream of the fence (Table 5). The total number of chinook removed from the river for hatchery broodstock was within the range required for hatchery production (Table 6). Age analysis of scale samples revealed the majority of chinook used in hatchery broodstock were three or four year olds, 63.8% and 35.6%, respectively (Table 7).

BIOLOGICAL DATA

A total of 60 male, 91 female and 102 jack chinook carcasses were recovered on the spawning grounds and measured for post orbital-hypural length (Table 8). The length of adult male chinook carcasses ranged from 37.3 to 76.6 cm and averaged 59.4 cm, while female carcasses ranged from 49.4 to 83.0 cm and averaged 66.8 cm. Jack chinook carcasses ranged in length from 28.0 to 67.2 cm and averaged 36.9 cm. A total of zero male, one female and two jack chinook (representing 0.0, 1.1% and 2.0%, respectively) recovered from the spawning grounds had clipped adipose fins (Table 8). The majority of adult chinook were three or four years old (46.7% and 46.7%, respectively) while most fish identified as jack chinook (90.4%) were two years old (Table 9).

A total of 65 male, 111 female and zero jack chinook were randomly collected from broodstock sampling (Table 10). Post orbital-hypural length measurements of male chinook ranged from 50.5 to 71.8 cm and averaged 58.9 cm while female chinook ranged from 50.6 to 81.0 cm and averaged 64.5 cm. One male and nine female chinook (1.5% and 8.1%, respectively) were missing adipose fins (Table 10).

No statistically significant difference was present when the lengths of male and female chinook carcasses recovered on the spawning grounds were compared to those samples obtained from hatchery broodstock (Student's t-test: $t = 0.392$; $p<0.01$ and $t=2.589$; $p<0.01$, for males and females respectively).

Analysis revealed no statistically significant difference in the adipose fin clip rate between female and male chinook carcasses recovered on the spawning grounds and those recovered from hatchery broodstock (Chi-square = 5.221; $p<0.01$ and Chi-square = 0.931; $p<0.01$, males and females respectively). A comparison between adipose fin clip rates obtained from fence video data and fall run hatchery broodstock also yielded no statistical differences (Chi-square = 0.859; $p<0.01$ and Chi-square = 0.878; $p<0.01$, for males and females respectively). Furthermore an adipose clip rate comparison between fence video data and

spawning ground chinook provided no statistical differences (Chi-square = 2.373; $p<0.01$, Chi-square = 3.096, $p<0.01$, Chi-square = 0.544; $p<0.01$, for males, females and jacks respectively).

Five chinook heads were collected from the spawning grounds for CWT analysis. Of the two adipose clipped chinook analysed, no CWT's were found. Two coded-wire tags were recovered from the remaining three adipose present chinook carcasses sampled. Both CWT chinook were adult females from the 1999 brood year and were released as part of the upper Cowichan River (late) release strategy (Table 11). A summary of all chinook releases from the Cowichan River Hatchery since 1979 is presented in Table 12.

ENVIRONMENTAL INFORMATION

Environmental data collected at the fence site included water temperature, visibility and water depth (Table 1). Water temperature was generally higher at the start of the study and decreased until November (Figure 3a). Water temperature over this period ranged from 6 to 20°C and averaged 13.5°C. Water depth at the fence site was consistently low with one peak on October 4. During the second week of November the water level continued to rise until fence removal (Figure 3b). Water depth over the study period ranged from 49 to 77 cm and averaged 54.2 cm. Water clarity was recorded in the form of a visibility code. For the majority of the study, visibility at the fence site was clear. Only four days were recorded as moderately cloudy (code 1-2) and four days as cloudy (Table 1).

River discharge was recorded at the Water Survey Canada station below the Island Highway Bridge in the City of Duncan (Table 13, Figure 1). River discharge during the course of the 2002 study was lower then the 30-year average from September to December (Figure 5).

CARCASS MARK-RECAPTURE

Between November 4 and November 29 a total of 60 male, 91 female and 102 jack chinook carcasses were tagged and released in the upper Cowichan River (Table 14a, 14b). Of the 31 carcasses recovered with tags, 7 (22.6%) were male, 13 (41.9%) were female, and 11 (35.5%) were jack chinook. Using the Petersen estimator, the adult chinook spawning ground population size was determined to be 1,245 fish (95% CI: 757 to 1,733), while the jack chinook population was estimated to be 979 fish (95% CI: 475 to 1,482) (Table 15).

Potential Biases

The assessment of sampling selectivity had several potential biases in the carcass mark-recapture study.

1. Temporal bias: Temporal bias in the tagging sample was examined by stratifying the mark incident rate into four recovery periods (Table 16). There was a significant temporal bias in the application sample for both male and female adult chinook when the data were stratified into

four equal recovery periods (Chi-square = 13.38; $p<0.01$ and Chi-square = 14.76; $p<0.01$, for males and females, respectively).

Temporal bias in the recovery sample was analysed by stratifying the recovery rates into four application periods (Table 17). A statistical difference in the recovery sample for both male and female adult chinook was observed (Chi-square = 26.70; $p<0.01$ and Chi-square = 20.55; $p<0.01$, males and females, respectively).

2. Fish Sex: Sex related bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries by application sample and by recovery sample. No sex related bias was evident when comparing male and female chinook populations (Chi-square = 0.22; $p<0.01$ and Chi-square = 0.17; $p<0.01$, application sample and recovery sample, respectively) (Table 18). When jack chinook were included in the application and recovery samples no significant bias was apparent (Chi-square = 0.57; $p<0.01$, and Chi-square = 0.45; $p<0.01$, application sample and recovery sample, respectively) (Table 19).

3. Size bias: Size related bias was examined by comparing the POH mean lengths of unrecovered marked chinook and recaptured chinook by sex. No size bias was evident in the recovery sample for adult male, adult female and jack chinook (Student's t-test: $t=2.310$; $p<0.01$, $t=0.762$; $p<0.01$, and $t=0.279$; $p<0.01$, for males, females and jacks respectively).

3. Location bias: Spatial bias was not examined due to insufficient sample size in the middle section of the river.

WATER MANAGEMENT PLAN

Cowichan River water releases started on October 02 and finished on October 08, 2002. Water was released from the Lake Cowichan Weir and increased gradually from 250 ft^3/s (7.1 m^3/s) to 450 ft^3/s (12.7 m^3/s) on October 02 and from 450 ft^3/s (12.7 m^3/s) to 650 ft^3/s (18.4 m^3/s) on October 03. Between October 03 and October 06 flow rates remained at 650 ft^3/s (18.4 m^3/s) with flows reduced to 450 ft^3/s (12.7m^3/s) on October 07. Flows were further reduced to 250 ft^3/s (7.1 m^3/s) on October 08. During this period, chinook upstream migration peaked on October 03 with 534 adults and 264 jacks enumerated at the fence site (Figure 3b).

POPULATION ESTIMATE

Escapement and total return estimates for 2002 were determined using fence count data since these are considered to be the most accurate enumeration method. However, after reviewing both spawning ground carcass recovery and hatchery broodstock collection data, it became evident that the chinook fence count did not accurately reflect the true jack to adult ratio. Analysing the lengths of jack and adult chinook with the traditionally accepted jack designated length of 450 mm revealed an overlapping of age groups (Figure 6). As a result, the spawning ground carcass recovery data were utilized to apportion the total chinook fence count with a more reflective ratio of jack and adult chinook within the population. This was accomplished by

comparing age data with length data to calculate the proportion of two year old jack chinook with lengths greater then 450 mm (4.5%) and the proportion of three year old or greater adult chinook with lengths of 450 mm or less (6.3%). The fence count data were then adjusted by these proportions yielding total chinook fence counts of 2,727 adults and 1,685 jacks. No adjustments were made to account for chinook arriving prior to installation or after fence removal leaving the final estimate of adult chinook migrating past the fence site at 2,727.

The number of naturally spawning adult chinook in the Cowichan River during 2002 was determined to be the fence count minus any broodstock removals or First Nations fishery catch from areas above the fence. Following this methodology, the total number of adult chinook spawning in the Cowichan River was estimated to be 2,505 fish (Table 20).

The total return of adult chinook to the Cowichan River was determined to be the sum of the total fence count with the addition of broodstock removals and the First Nations fishery catch. A further 300 fish were added to this total to account for chinook lost to seal predation in the Cowichan estuary (see discussion for details). Following this methodology, the total return of adult chinook to the Cowichan River was estimated to be 5,785 fish (Table 20).

DISCUSSION

ENUMERATION FENCE

The floating fence design functioned well in the flow conditions that existed in the lower Cowichan River during the fall of 2002. While the fence was intended to be self-cleaning, field staff were required to regularly remove leafy debris from the fence panels during periods of heavy rain and related high flows. During such periods, fence panels became over burdened and could not remain afloat without the removal of debris. While this difficulty has been observed in other fence studies (Cousens et al. 1982, Johnston et al. 1986) it is likely that the extent of the problem varies by year and location.

During many of the past monitoring studies, high flows have caused fence damage or forced early removal resulting in incomplete fence counts. During the current study, the enumeration fence was operational throughout the monitoring period and a complete count of all fish passing the site was attained. Past studies have indicated that approximately 15% of the chinook run arrives after October 30 (Nagtegaal and Carter 1998) and this proportion is usually incorporated into the final estimate of chinook migration past the fence. In the current study, no additional expansion was made to the fence enumeration estimate to adjust for an incomplete fence. Furthermore, the 2002 study enumerated 24% of total chinook fence counts after October 30, 9% greater than the previously noted 15%.

Several of the past fence enumeration studies conducted on the Cowichan River have noted the mis-identification of jack versus adult chinook by observers monitoring the migration of chinook past the fence (Nagtegaal and Carter 1998, 2000). While trap box verifications of observer counts were not carried out in 2002, it became clear from both spawning ground and hatchery broodstock data that the adult to jack ratio recorded at the fence was not reflective of the

true population parameters. Since there were a number of jack chinook at the upper end of the size distribution, it appears as if some of these fish were counted as adults. This seems likely as it would be very difficult to determine the size of a moving fish to within a few centimetres when viewing them from a counting tower well above the river. As a result, the total chinook fence count was adjusted by the ratio of adult and jack chinook sampled during the spawning ground carcass recovery.

Video Enumeration Data

Video data from the fence site provided an independent audit of species identification as well as adult and jack chinook enumeration. Only a partial comparison was made between the video and the observer fence data due to the camera not operating the entire length of the enumeration study. Chinook counts and total fish counts deviated less than 5% from fence observer data while adult and jack ratios differed by more than 14%. This variation in adult and jack ratios may be due to methodological differences as video analysis based sex differentiation on morphology and fence observers used length to define a jack chinook. The tendency for video analysis to record difficult to identify chinook as an unknown sex (36.0%) may skew jack and adult ratios obtained from video data.

SWIM SURVEYS

Among the biases typically associated with swim surveys, the extrapolation of actual swim counts to total estimates warrants some consideration (Burns unpubl.). Assumptions concerning the distribution of chinook in the river at the time of the survey are the basis for expanding these counts to estimate total escapement (T. Fields, 230 Underwood St., Duncan, B.C. V9L-3X3; pers. comm.). In 1991, it became apparent that during high water flow conditions in early fall, expansions based on the swim survey results overestimated total escapement (Nagtegaal et al. 1994b). The results of the 1992 swim surveys support the hypothesis that during low water flow conditions in late fall, expansions based on swim survey results underestimate the number of spawners (Nagtegaal et al. 1994c). Low flow conditions lead to underestimation of spawners because the distribution of fish in the river is affected by flow. Generally, in low water years, not as many fish make it to the traditional spawning areas above Skutz Falls. The expansion of swim surveys conducted in the upper area alone tends to underestimate the number of fish. Conversely, during high water years most of the fish make it above Skutz Falls so the expansion factor tends to overestimate the number of fish.

The 2002 swim survey expanded estimate of 1,421 is considerably lower than the natural spawning estimate of 2,505 adult chinook. This could partially be explained by low river flows, which would result in an under-estimation of adult chinook. It should also be noted that only one swim survey was conducted in one section of the river therefore conclusions from these data are limited.

FIRST NATIONS FOOD FISHERY

Catch estimation procedures developed by the Cowichan Tribes Aboriginal Fisheries Management unit have not been assessed by stock assessment staff. As a result, no comments can be made regarding the methodologies used. Discussions involving CTAF and DFO resulted in a final First Nations food fishing estimate of 1,500 adult chinook. The current food fishing estimate of 1,500 chinook was an increase over 2001 estimates (Table 4).

BIOLOGICAL DATA

Male and female chinook collected by the hatchery for broodstock were not statistically different in length than the carcasses recovered on the spawning ground. This suggests the retrieval method used at the spawning grounds and the beach seine method used in broodstock capture were both relatively non-selective for size.

Statistical analysis revealed no difference in the adipose fin clipped rates of both male and female chinook collected from the spawning grounds or those collected for hatchery broodstock. An adipose clip rate comparison between fence video analysis and both hatchery broodstock and spawning grounds sampled chinook also yielded no statistical differences. This suggests adipose fin status did not bias fish collection at either the spawning grounds or at the hatchery.

The two CWT adipose present chinook obtained from the spawning grounds are part of a double index tagging (DIT) study taking place in the Cowichan River. The DIT study's purpose is to investigate a potential difference in survival rates between clipped fish with CWT's and unclipped fish with CWT's. During the DIT study both adipose present and adipose clipped fish are tagged with CWT's and released from the Cowichan River Hatchery. DIT study information may be used in deciding whether adipose clipping hatchery fish is a viable option in hatchery only retention fisheries and to assess if differential mortality occurs between adipose clipped and non-adipose clipped fish.

MARK-RECAPTURE

The carcass mark-recapture portion of the Cowichan River chinook stock assessment project was implemented many years ago for several reasons. First, since handling fish at the fence site caused significant migration delays this practice was abandoned to ensure chinook reached the spawning grounds without undue stress. While length, age and sex data were collected by hatchery staff during broodstock capture, these data were not consistently representative of the spawning population. The sampling of carcasses from the spawning ground provided an additional source of biological data, which when pooled with the hatchery sample was more representative of the true population. Second, the recovery of coded-wire tags from hatchery broodstock did not provide an adequate sample size for a rigorous assessment. Spawning ground carcass recoveries yield additional coded-wire tagged fish. Finally, since high flows in past years have caused fence damage that resulted in incomplete enumeration of spawners, an additional method of providing a population estimate was required.

Population estimates for adult and jack chinook were determined using the pooled Petersen estimator. Since the true population size was not known, a direct measure of the accuracy of the estimates was not possible. However, an assessment of the underlying assumptions of equal probability of capture, simple random recovery sampling and complete mixing can usually be made by testing recovery and application samples for temporal, spatial, sex and size related biases (Schubert 2000). To carry out most of the bias assessments, different gear types must be utilized for capturing the tag application and the recovery samples. In the current study, the spawning ground carcass recovery was used to obtain both samples thus limiting the ability to assess sample biases.

The assessment of sampling selectivity revealed several biases in the carcass mark-recapture study. There was a significant temporal bias in the application sample for both male and female chinook. The assessment revealed that tag incidence was very low during the early period and higher during the last period. This is likely due to the nature of the carcass recovery study, since tagging and recovery were concurrent activities. As a result, there were very few tagged carcasses available for recovery in the early period and as the number of tags in the population accumulated towards the end of the study, the tag incidence in the later periods was much higher. There was also a temporal bias in the recovery sample for males and females. Once again this bias was primarily due to the nature of the study since more tagged fish were available for recapture during the later periods of the study.

No sex related bias was evident in the application or recovery samples for adult chinook or when jack chinook were included in the assessment. In the past years jack chinook were recovered proportionally less than adult chinook. This was likely due to the size difference between adult and jack chinook, which effects the way carcasses behave in the river. Since jack carcasses are much smaller, they are more easily flushed out of the recovery area by small increases in river flow. However, during the course of the November 2002 spawning ground recovery a large increase in river flow was noted with initial flow rates of 5.1 m^3/s rising to a peak of 178.7m^3/s. This sharp increase in flow could attribute to various sizes of carcasses being washed away at an equal rate.

Size bias testing did not provide an assessment of the size selectivity of the sampling method since both application and recovery samples were obtained using the same method. Rather, the size bias assessment provided an evaluation of the recoverability, based on size, of tagged carcasses that were redistributed back into the river after tagging. Testing revealed that there was no size bias for male, female, or jack chinook.

Bias associated with location was not tested due to insufficient sample size in the middle section of the river. This may have been due to cloudy water conditions making carcass recoveries difficult, although some carcasses were found along the sides of the river. Erosion of clay banks, which exist in this segment of the river, cause the water to be very cloudy and substantially reduces water visibility. Conditions for recovering carcasses further deteriorate as water flow increases. Although location bias could not be tested, marked fish have been recovered by sports fisherman well downstream of the study area. This suggests some tagged specimens were not available for recapture and were probably flushed out of the study area due to

higher than average water flow (Figure 5). A reduction in the ability to recapture tagged carcasses would contribute to an overestimation of the actual chinook population.

The detection of sampling biases usually results in the use of a stratified estimator; however, Schubert (2000) compared the performance of several mark-recapture population estimators for a sockeye salmon population of known abundance and concluded that the pooled Petersen estimator was less biased and preferred over stratified estimators. In that study, the Schaeffer estimator would not improve accuracy and it was recommended that the method be abandoned for use in population estimation. Also, it was determined that while the maximum likelihood Darroch estimator could potentially improve accuracy there was no obvious way of selecting between accurate and highly biased estimates. Parken and Atagi (2000) found that pooled and stratified estimators of Nass River summer steelhead produced similar escapement estimates but that the pooled estimator was more precise and had less statistical bias than the stratified estimator. These findings highlight the robust nature of the pooled Petersen estimator and suggest that its usage in determining population abundance from mark-recapture data is generally appropriate under a wide range of circumstances.

WATER MANAGEMENT PLAN

The scheduled water release during October 02 and October 08 was gradually increased and decreased in order to minimise the effects associated with a sudden rise in river levels. This release resulted in a migration peak as fish holding below the enumeration fence swam upstream during this brief period of increased river discharge.

SEAL PREDATION

Although seal predation was not directly assessed in this study, it is worthwhile to examine the impact seals have on chinook in Cowichan Bay. In 1988, the number of seals gradually increased from a low of 30 in April to a peak of about 100 in December. According to Olesiuk et al. (1990) harbour seals consume an estimated 9 tonnes of salmon annually in Cowichan Bay. An estimated 23% (September) to 48% (November) of the harbour seals' diet in Cowichan Bay was comprised of salmon (Bigg et al. 1990). Based on these data, consumption of chinook salmon could potentially range from 100 to 500 adults. These data were collected in 1988 when low flows in the Cowichan River persisted until the end of October. Predation likely increases the longer chinook salmon remain in the estuary waiting for high water to allow upstream migration. While low flow conditions occurred during September to November 2002, Fishery Officers observations indicated that seal and sea lion populations have remained constant for the last couple of years in Cowichan Bay. As a result, predation on chinook was estimated to be approximately 300 adults.

Fishery Officers also noted a pod of killer whales feeding in Cowichan Bay for approximately 24 hours. Their affect on chinook populations could not accurately be assessed.

POPULATION ESTIMATE

The 2002 Cowichan River chinook population estimate was based on the enumeration fence count. Low and moderate river flows allowed the fence to remain in place without significant breaches for the duration of the study and it was felt that a near complete census was attained. The estimated number of natural spawning adult chinook migrating past the fence site of 2,505 was above the 95% confidence limits of the 757-1,733 adult chinook mark-recapture estimate. This result is consistent with past projects (Nagtegaal and Carter 1998, 2000) which have fence estimates above mark-recapture estimates. Since the mark-recapture study was conducted in the upper river only (the main spawning area) any chinook that spawned in other areas of the watershed were not included, therefore this estimate would not include all chinook migrating past the fence.

The estimated number of adult spawners was the third lowest since 1975, below the period average of 5,651 and well below the revised escapement goal of 7,400 (Riddell et al. 2000) (Table 20, Figure 7). Hatchery releases of chinook fry were over 2.5 million for both 1998 and 1999 brood years (Figure 8). The enhanced contribution was calculated to be 78.6% of the total adult chinook return. This estimate is thought to be biased high due to the small number of carcasses recovered in the mark-recapture portion of this study coupled with large expansion factors for marked to unmarked fry release ratios. Hatchery and natural contributions for Cowichan River chinook escapement are summarized by year in Figure 9. The total chinook estimate of 5,785 was below the period average of 7,232 (Table 20).

ACKNOWLEDGEMENTS

We would like to thank Stefan Deleeuw, James Patterson, Phil Joe, Candace Boyle, Dave Burton, Ashley Pifko, Frank Sutherland, Chad Stewart, Shawn Stenhouse, and Doug August for their involvement in the implementation of the enumeration fence, collection of migration and biological data. We thank W. Jansen and E. Teskey, Fisheries and Oceans Canada Fishery Officers stationed in Duncan, for their helpful assistance. We thank the Cowichan Tribes Fisheries Management Unit, in particular Wayne Paige and Wayne Paige Jr. for their cooperation and assistance in acquiring First Nations food fishery data and swim survey results. We thank Don Elliot, manager of the Cowichan River Hatchery, for providing broodstock capture and biosampling data. We thank the conscientious sport fishers who returned the Ketchum tags from the chinook they caught in the Cowichan River. We thank the City of Duncan for allowing us to use their access road to the counting fence site and granting us storage space, power and water from their pumphouse facility. We thank F. Voysey, from Fisheries and Oceans Canada, W. Van Bruggen, the Regional Water Manager for British Columbia as well as M. Vessey and G. Kissack from NorskeCanada for co-ordinating the water release management plan for the Cowichan River.

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Table 1. Daily counts at the Cowichan River fence site, 2002

Date	Visibility[1]	Temp (^{0}C)	Depth (cm)	Chinook		Coho		Chum	Unknown
				Adult	Jack	Adult	Jack		
03-Sep	1	18.0	N/A	0	0	0	0	0	0
04-Sep	1	17.5	51.0	1	1	0	0	0	0
05-Sep	1	16.0	51.0	2	0	0	0	0	0
06-Sep	1	16.3	50.3	0	1	0	0	0	0
07-Sep	1	16.0	50.3	1	0	0	0	0	0
08-Sep	1	16.3	50.0	0	1	0	0	0	0
09-Sep	1	16.7	50.0	0	0	0	0	0	0
10-Sep	1	17.0	52.7	6	4	0	0	0	0
11-Sep	1	18.3	54.0	25	14	0	0	0	0
12-Sep	1	16.7	53.0	21	9	0	0	0	0
13-Sep	1	15.7	53.7	69	24	0	0	0	0
14-Sep	1	18.3	53.0	38	21	0	0	0	0
15-Sep	1	18.0	53.0	15	15	0	0	0	0
16-Sep	1	16.7	53.3	19	33	0	0	0	0
17-Sep	1	15.7	53.0	23	10	0	0	0	0
18-Sep	1	16.0	53.3	24	13	0	0	0	0
19-Sep	1	17.0	54.0	20	14	0	0	0	0
20-Sep	1	16.3	54.0	12	5	0	0	0	0
21-Sep	1	15.7	53.7	17	14	0	0	0	0
22-Sep	1	15.7	53.0	16	14	0	0	0	0
23-Sep	1	16.3	53.0	49	39	1	2	0	0
24-Sep	1	15.7	53.0	12	14	2	0	0	0
25-Sep	1	16.0	53.0	28	17	0	0	0	0
26-Sep	1	15.7	54.0	17	5	3	2	0	0
27-Sep	1	15.7	53.0	13	1	1	1	0	0
28-Sep	1	16.0	53.0	10	4	0	0	0	0
29-Sep	1	16.7	53.0	12	7	1	6	0	0
30-Sep	1	14.7	53.7	30	10	3	5	0	0
01-Oct	1	14.0	53.0	31	7	2	2	0	1
02-Oct	1	13.7	54.7	11	7	0	1	0	1
03-Oct	2	14.7	64.7	534	264	8	14	0	4
04-Oct	2	15.0	67.0	243	97	28	13	0	0
05-Oct	1-2	16.0	66.0	62	11	29	5	0	1
06-Oct	1	16.3	65.7	42	12	28	7	0	1
07-Oct	1	16.0	64.0	115	21	59	11	0	0
08-Oct	1	15.0	60.7	139	29	32	9	0	6
09-Oct	1	15.3	54.0	29	5	22	3	0	0
10-Oct	1	13.7	53.3	28	6	10	0	0	0
11-Oct	1	12.0	53.0	35	1	10	4	0	0
12-Oct	1	11.7	53.0	11	3	9	1	0	0
13-Oct	1	10.7	53.3	5	4	1	4	0	0
14-Oct	1	11.7	53.0	12	1	5	2	0	0
15-Oct	1	11.7	53.0	16	6	3	5	0	0
16-Oct	1	12.3	52.7	10	5	8	2	0	0
17-Oct	1	12.3	53.0	19	13	21	4	0	1
18-Oct	1	12.3	53.0	6	9	6	5	1	0
19-Oct	1	12.3	52.3	10	7	8	1	2	1

Table 1. (continued)

Date	Visibility[1]	Temp (°C)	Depth (cm)	Chinook		Coho		Chum	Unknown
				Adult	Jack	Adult	Jack		
20-Oct	1	13.0	52.7	19	12	4	2	1	0
21-Oct	1	14.0	53.3	23	11	25	8	2	0
22-Oct	1	13.7	53.0	41	28	109	11	2	0
23-Oct	1	11.7	53.0	19	14	61	16	4	2
24-Oct	1	10.7	53.0	28	5	64	6	1	0
25-Oct	1	10.7	53.0	10	4	27	3	11	0
26-Oct	1	11.3	52.3	7	18	23	3	3	1
27-Oct	1	11.3	52.3	42	27	26	5	18	0
28-Oct	1	11.0	53.3	21	19	44	7	40	0
29-Oct	1	10.3	52.7	31	21	82	30	18	0
30-Oct	1	7.7	52.3	12	10	37	4	28	0
31-Oct	1	7.3	52.3	6	4	6	2	10	0
01-Nov	1	7.7	52.0	14	21	13	3	123	141
02-Nov	1	8.0	51.7	20	15	14	3	234	0
03-Nov	1	7.3	50.3	29	27	6	3	285	0
04-Nov	1	6.7	50.0	26	40	6	3	719	0
05-Nov	1	9.3	49.7	60	113	30	10	1623	0
06-Nov	1	10.0	51.3	127	193	53	16	7741	0
07-Nov	1	10.3	53.0	90	106	239	55	8011	0
08-Nov	1	10.3	54.3	61	60	360	90	12901	0
09-Nov	1-2	10.0	56.0	78	48	568	59	16901	0
10-Nov	1-2	10.0	55.3	44	32	220	29	11047	0
11-Nov	1-2	10.0	62.0	27	17	331	48	7013	0
12-Nov	2-3	10.0	76.0	71	23	969	65	12209	0
13-Nov[2]	2	10.0	77.0	1	1	190	12	1004	0
Totals				2745	1667	3807	602	79952	160

[1] Visibility Code: 1 = clear; 2 = cloudy.
[2] Partial enumeration from 0000-0600 hours.

Table 2. Counts by time interval at the Cowichan River fence, 2002.

Time Period	Chinook				Coho					
	Adult		Jack		Adult		Jack		Chum	
	Count	%	Count	%	Count	%	Count	%	Count	%
0000 - 0100	129	4.7	74	4.4	200	5.3	46	7.6	3366	4.2
0100 - 0200	136	5.0	104	6.2	171	4.5	46	7.6	3181	4.0
0200 - 0300	165	6.0	87	5.2	177	4.6	42	7.0	2382	3.0
0300 - 0400	145	5.3	63	3.8	132	3.5	43	7.1	2344	2.9
0400 - 0500	118	4.3	57	3.4	119	3.1	21	3.5	1974	2.5
0500 - 0600	122	4.4	50	3.0	114	3.0	21	3.5	1910	2.4
0600 - 0700	230	8.4	171	10.3	111	2.9	28	4.7	1755	2.2
0700 - 0800	335	12.2	202	12.1	165	4.3	33	5.5	7118	8.9
0800 - 0900	191	7.0	79	4.7	62	1.6	9	1.5	5001	6.3
0900 - 1000	159	5.8	53	3.2	57	1.5	7	1.2	5255	6.6
1000 - 1100	59	2.1	24	1.4	99	2.6	5	0.8	5969	7.5
1100 - 1200	43	1.6	19	1.1	181	4.8	27	4.5	5140	6.4
1200 - 1300	36	1.3	25	1.5	198	5.2	15	2.5	4401	5.5
1300 - 1400	54	2.0	11	0.7	245	6.4	10	1.7	2720	3.4
1400 - 1500	26	0.9	26	1.6	232	6.1	23	3.8	3009	3.8
1500 - 1600	35	1.3	30	1.8	191	5.0	13	2.2	1900	2.4
1600 - 1700	43	1.6	29	1.7	216	5.7	12	2.0	1278	1.6
1700 - 1800	77	2.8	73	4.4	117	3.1	16	2.7	662	0.8
1800 - 1900	78	2.8	53	3.2	97	2.5	16	2.7	584	0.7
1900 - 2000	54	2.0	62	3.7	149	3.9	34	5.6	2628	3.3
2000 - 2100	89	3.2	72	4.3	172	4.5	31	5.1	4144	5.2
2100 - 2200	141	5.1	70	4.2	161	4.2	25	4.2	3518	4.4
2200 - 2300	154	5.6	111	6.7	203	5.3	37	6.1	5272	6.6
2300 - 2400	126	4.6	122	7.3	238	6.3	42	7.0	4441	5.6
Total	2745	100	1667	100	3807	100	602	100	79952	100

Table 3. Visual survey data collected for the Cowichan River, 1981-2002.

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
1981	S	Sept. 12	175		208	1000	2-4
	S	Oct. 2	103		93	1500	2-4
	S	14	364		1160	4000	2-4
	H	22			2000		1-7
	S	23			3200	5000	2-4
Estimate for Season[3]						5500	
1982	S	Sept. 14	199		131	600	2-4
	S	Oct. 13			153		2-4
	H	19	saw few fish on spawning grounds				1-13
	F	Nov. 8				4000	
Estimate for Season						4500	
1983	S	Sept. 8	38		61	254	2-6
	S	15	62		121	504	2-6
	S	28	190		470	1838	1-2
	S	Oct. 7	207		425	1804	2-6
	S	14	802		997	2836	2-7
	S	25	901		1113	4500	1-6
Estimate for Season						4500	
1984	S	Aug. 28	80		84	400	2-5
	S	Sept. 6	25		72		
	S	13	79		80		3-11
	S	19	35		71		2-6
	S	26	291		434		2-6
	S	Oct. 3	205		283		3-7
	S	"	206		282	2200	8-11
	S	23	525		1300	5000	1-6
	S	Nov. 1	350		1276		1-6
Estimate for Season						5000	
1985	S	Sept. 12	39		46	220	2-6
	S	17	42		10		12-13
	S	18	210		33		2-6
	S	27	245		104	456	2-6
	S	Oct. 3	244		99	360	2-6
	S	10	285		219		2-6
	S	16	293		347		2-6
	S	31	229		934	3500	1-6
Estimate for Season						3500	
1986	S	Sept. 9	295		85	300	2-6
	S	18	46		29	300	3-6
	S	24	161		56	350	12-13
	S	Oct. 7	1310		223	1000	2-6
	S	29	613		473	1200	1-6
	S	Nov. 6	1178		491	1200	
	H	8			515		1-13
Estimate for Season						1200	

Table 3. (continued)

				Chinook				
				Jacks		Adults		
	Method[1]	Date		Count	Estimate	Count	Estimate	River Segment[2]
1987	S	Sept.	9	30	300	10	50	3-8
	S		17	111		16	75	2-6
	S		25	112		16	75	3-6, 11-12
	S	Oct.	6	196	800	115	400	2-6
	S		15	196		96		1-6
	H		16		saw very few spawners			1-13
	S		28	417		468		1-6
	S	Nov.	6	329		649		1-6
Estimate for Season							1200	
1988	S	Aug.	25	100		50		2-6
	S	Sept.	1	271		149	700	2-6
	S		23	1464		271	1000	2-6
	S	Oct.	3	821	1600	1094	3500	2-6
	S		14	2008		2076	4000	1-6
Estimate for Season							5500	
1989	S	Sept.	11	151		58	300	2-6
	S		21	95		39	350	3-6
	S	Oct.	5	95		48	700	2-3
	S		18	719		350	1200	2-6
	S	Nov.	1	1537		2267		2-6
Estimate for Season							5000	
1990	S	Aug.	29	254		54	250	2-6
	S	Sept.	14	385		89	1000	3-6
	S		27	3169		477	2200	2-3
	S	Oct.	19	4297		2382	5000	2-6
Estimate for Season							5300	
1991	S	Sept.	19			1882	6000	2-6
	S	Oct.	2			2873	7500	2-6
	S		17			2924	8700	2-6
	S		31			3502[4]	9000	2-6
Estimate for Season							10000	
1992	S	Sept.	16	5		8		2-5
	S	Oct.	2	124		46	200	2-6
	S		15	359		291	700	2-6
	S		15	113		162		2-6
	S		27	514		797	2000	1-6
	S		28	591		767		1-6
	S	Nov.	13	506		467		1-6
	S		13	450		640[5]		1-6
Estimate for Season							7500	

Table 3. (continued)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
1993	S	Sept. 23	23		14	47	2-6
	S	30	81		62	210	2-6
	S	Oct. 14	207		199	676	2-6
	S	28	127		327	1111	2-6
	S	Nov. 4	480		987	3355	
Estimate for Season[6]						5200	
1994	S	Aug. 24	39		3		2-6
	S	Sept. 14	67		46	156	2-6
	S	28	421		323	1098	2-6
	S	Oct. 13	1253		1146	3896	2-6
	S	26	442		1450	4930	2-6
Estimate for Season[6]						5500	
1995	S	Sept. 28	294		267	1170	2-6
	S	Oct. 25	490		1798	6653	2-6
Estimate for Season[6]						15500	
1996	S	Sept. 13	45		46	147	2-6
	S	26	166		150	510	2-6
	S	Oct. 2	254		534	1815	2-6
	S	9	579		1157	3933	2-6
	S	15	195		707	2403	2-6
	S	22	557		1699	5776	2-6
Estimate for Season[6]						6500	
1997	S	Sept. 23	165		358	1217	2-6
	S	Sept. 25	87		404	1373	2-6
	S	Sept. 30	54		509	1730	2-6
	S	Oct. 16	84		289	980	2-6
	S	Oct. 23	1036		1831	6225	2-6
Estimate for Season[5]						6500	
1998	S	Sept. 25	72		37		2-6
	S	Oct. 13	54		53		2-6
	S	Oct. 20	130		857	2913	2-6
	S	Oct. 26	317		1260	4284	2-6
Estimate for Season						4284	
1999	S	Sept. 10	88		46	221	2-6
	S	Oct. 13	321		342	1641	2-6
Estimate for Season						4500	
2000	S	Sept. 13	33		25	N/A[7]	2-6
Estimate for Season						3069	
	S	Sept. 26	80		230	782	Lower[8]
	S	Oct. 19	439		940	3196	1-6
2001	S	Oct. 23	135		255	867	2-6
Estimate for Season						3282	

Table 3. (continued)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
2002	S	Oct. 25	111		418	1421	2-3
Estimate for Season						2505	

[1]S - Swim survey, H - Helicopter survey, F - boat survey
[2]Refer to Figure 1.
[3]Total escapement estimate for adult chinook.
[4]516 chinook carcasses were counted in this total.
[5]28 chinook carcasses were counted in this total.
[6]Swim surveys conducted by Cowichan Tribes River Management Unit, total escapement determined by Fishery officers.
[7]Adult population estimate based on swim survey records was not feasible due to extremely low water conditions during swim survey.
[8]Swim survey took place in the lower Cowichan River from Black Bridge to Green Point (Figure 2).

Table 4. Annual adult and jack chinook catch estimates from the Cowichan River First Nations food fishery[1], 1981-2002.

Year[2]	Chinook Catch	
	Adult	Jack[3]
1971	725	
1972	700	
1973	900	
1974	1000	
1975	900	
1976	1000	
1977	1000	
1978	500	
1979	500	
1980	1500	
1981	1500	1500
1982	1000	1000
1983	250	1000
1984	355	700
1985	1000	1000
1986	800	800
1987	800	800
1988	681	450
1989	1055	250
1990	820	150
1991	450	70
1992	900	12
1993	650	22
1994	700	227
1995	533	120
1996	810	150
1997	191	N/A
1998	1073	N/A
1999	233	89
2000	89	N/A
2001	918	120
2002	1500	N/A

[1] Includes chinook caught in both the spear fishery and the in-river gillnet fishery.
[2] Since 1988, data has been collected by the Cowichan Tribes River Management unit. Prior to 1988, data were collected by local Fishery Officers.
[3] Estimates for jack chinook were not provided in 1997, 1998 and 2000.

Table 5. Summary by day and location of chinook broodstock collection by Cowichan River Hatchery staff during 2002.

Date	Below Fence			Above Fence		
(dd/mm/yy)	Male	Jack	Female	Male	Jack	Female
23/09/02	54	0	52	4	0	13
23/09/02	36	0	40	3	0	4
24/09/02	80	0	64	2	0	2
25/09/02	28	0	29	0	0	0
27/09/02	123	0	118	2	0	6
30/09/02	33	0	27	7	0	12
01/10/02	57	0	33	9	0	16
01/10/02	14	0	7	5	0	3
02/10/02	9	0	19	7	0	7
03/10/02	14	0	10	1	0	1
07/10/02	13	0	18	3	0	2
08/10/02	55	0	33	19	0	24
09/10/02	32	0	22	0	0	1
10/10/02	13	0	11	12	0	20
11/10/02	7	0	4	2	0	8
15/10/02	66	0	99	10	0	14
21/10/02	0	0	17	0	0	0
21/10/02	2	0	19	0	0	3
Total	636	0	622	86	0	136

Table 6. Annual hatchery broodstock collection of adult and jack Cowichan River chinook, 1981-2002.

Year	Chinook Broodstock Collection	
	Adult	Jack[1]
1981	282	
1982	534	
1983	242	
1984	278	
1985	175	
1986	315	
1987	582	
1988	678	30
1989	535	96
1990	327	1
1991[2]	1755	347
1992	1850	77
1993	2200	228
1994	1357	145
1995	2149	512
1996	1615	258
1997	125	79
1998	1485	201
1999	1659	1
2000	1529	14
2001	1732	0
2002	1480	0

[1] Barry Cordecedo (Salmonid Enhancement Program) provided numbers on broodstock collection from 1981 to 1987. The broodstock numbers provided included jacks, but no reliable records were kept. It was estimated that for most years about 10 to 15 jacks were collected. These estimates were subtracted from the broodstock numbers resulting in an estimate of the number of adult chinook removed from the system.

[2] In addition, 284 males were removed for broodstock but later returned to the river.

Table 7. Summary of age by sex for Cowichan River chinook collected from hatchery broodstock during 2002.

	Male		Female		Total Adult		Jack	
Age	#	%	#	%	#	%	#	%
2	0	0.0%	0	0.0%	0	0.0%	0	0.0%
3	44	84.6%	51	52.6%	95	63.8%	0	0.0%
4	8	15.4%	45	46.4%	53	35.6%	0	0.0%
5	0	0.0%	1	1.0%	1	0.7%	0	0.0%
Total	52	100%	97	100%	149	100%	0	0%

Table 8. Length-frequency of chinook sampled on the Cowichan River spawning grounds, 2002.

Length (cm)	Males	Jacks	Females
28	0	2	0
29	0	1	0
30	0	1	0
31	0	4	0
32	0	9	0
33	0	5	0
34	0	11	0
35	0	8	0
36	0	10	0
37	1	14	0
38	0	9	0
39	0	8	0
40	0	8	0
41	0	4	0
42	0	4	0
43	0	0	0
44	0	1	0
45	0	1	0
46	0	0	0
47	0	0	0
48	5	0	0
49	2	0	1
50	1	0	0
51	1	0	0
52	2	0	0
53	5	0	0
54	2	0	3
55	2	0	0
56	1	0	0
57	3	0	4
58	4	0	3

Table 8. (continued)

Length (cm)	Males	Jacks	Females
59	1	0	3
60	5	0	3
61	3	0	4
62	2	0	2
63	4	0	6
64	2	1	2
65	0	0	6
66	2	0	1
67	2	1	4
68	2	0	9
69	0	0	5
70	2	0	4
71	1	0	10
72	0	0	6
73	1	0	6
74	0	0	3
75	2	0	3
76	1	0	1
77	1	0	0
78	0	0	0
79	0	0	1
80	0	0	0
81	0	0	0
82	0	0	0
83	0	0	1
Total	60	102	91
Mean Length (cm)	59.4	36.9	66.8
Adipose Fin Clips	0	2	1
Fin Clip Rate	0.0%	2.0%	1.1%

Table 9. Summary of age by sex for Cowichan River chinook collected from the spawning grounds during 2002.

		Male		Female		Total Adult		Jack	
European Age	Total Age	#	%	#	%	#	%	#	%
00	1	0	0.0%	0	0.0%	0	0.0%	1	1.1%
01	2	3	5.8%	1	1.4%	4	3.3%	85	90.4%
02	3	38	73.1%	19	27.1%	57	46.7%	8	8.5%
03	4	11	21.2%	46	65.7%	57	46.7%		
04	5			4	5.7%	4	3.3%		
Total		52	100%	70	100%	122	100%	94	100%

Table 10. Length-frequency of chinook broodstock collected by the Cowichan River Hatchery, 2002.

Length (cm)	Males	Jacks	Females
50	1	0	0
51	4	0	4
52	2	0	1
53	3	0	0
54	6	0	1
55	3	0	0
56	5	0	1
57	3	0	6
58	7	0	4
59	6	0	9
60	2	0	4
61	1	0	10
62	5	0	7
63	5	0	5
64	3	0	7
65	0	0	4
66	3	0	6
67	2	0	7
68	2	0	9
69	1	0	3
70	0	0	7
71	0	0	1
72	1	0	5
73	0	0	0
74	0	0	1
75	0	0	3
76	0	0	3
77	0	0	2

Table 10. (continued)

Length (cm)	Males	Jacks	Females
78	0	0	0
79	0	0	0
80	0	0	0
81	0	0	1
Total	65	0	111
Mean Length (cm)	58.9	-	64.5
Adipose Fin Clips	1	0	9
Fin Clip Rate	1.5%	0.0%	8.1%

Table 11. Release and recovery data for coded-wire tags recovered from Cowichan River chinook sampled on the spawning grounds during 2002.

Recovery Data					Release Data			
Date (dd/mm/yy)	Location	Adipose Clipped	POH Length (mm)	Sex	Brood Year	Tag Code	Location [1]	Date (dd/mm/yy)
04/11/02	10	N	754	F		No Pin		
05/11/02	12	N	575	F	99	183127	Upper Cowichan R. (late)	17/05/00
22/11/02	58	Y	338	J		No Data		
25/11/02	14	Y	360	J		No Pin		
28/11/02	31	N	540	F	99	183124	Upper Cowichan R. (late)	28/04/00

[1] Cowichan Hatchery release strategies for chinook:
Upper Cowichan River (late): raised to pre-smolt size (5-6 g) prior to release approximately 3 km below the weir in May.

Table 12. Cowichan River Hatchery chinook release[1] data for brood years 1979-2001.

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
021846	1979	31628	32134	98.4	2.8		1980/05/07	COWICHAN R
022060	1979	32034	32547	98.4	2.8		1980/05/07	SKUTZ FALLS
022158	1980	52519	65000	80.8	2.3		1981/06/09	COWICHAN R
022307	1981	30179	30373	99.4	3.1		1982/05/12	COWICHAN R
022339	1982	49135	224944	21.8	2.9		1983/05/14	SKUTZ FALLS
022831	1983	50613	101000	50.1	4.27		1984/05/25	KOKSILAH R
NOCN8311	1983		200000	0.0	4.27		1984/05/31	COWICHAN R
NOCN8411	1984		187823	0.0	4.8	1985/05/13	1985/05/14	COWICHAN R
023803	1985	25365	25804	98.3	4.26	1986/05/23	1986/05/24	COWICHAN R
023804	1985	25455	25895	98.3	4.26	1986/05/23	1986/05/24	COWICHAN R
023911	1985	11980	12187	98.3	4.26	1986/05/23	1986/05/24	COWICHAN R
NOCN8619	1986		321172	0.0	4	1987/05/13	1987/05/22	COWICHAN R
NOCN8620	1986		54608	0.0	3.48		1987/05/21	KOKSILAH R
024334	1987	14298	14334	99.7	3.41		1988/04/18	COWICHAN R
024729	1987	25360	25424	99.7	3.4		1988/04/18	COWICHAN R
024730	1987	25869	25934	99.7	3.4		1988/04/18	COWICHAN R
024731	1987	27428	27497	99.7	7.1	1988/04/18	1988/05/18	COWICHAN LK
024732	1987	27271	27339	99.8	7.1		1988/05/18	COWICHAN LK
024733	1987	26911	26978	99.8	7.1		1988/05/18	COWICHAN LK
024734	1987	23521	23580	99.7	7.1		1988/05/18	COWICHAN LK
024735	1987	26719	26786	99.7	3.4	1988/04/18	1988/05/18	COWICHAN R
024945	1987	26461	123361	21.5	7.49	1988/05/25	1988/05/26	COWICHAN R UP
024946	1987	26658	123560	21.6	7.49	1988/05/25	1988/05/26	COWICHAN R UP
024947	1987	26761	123663	21.6	7.49	1988/05/25	1988/05/26	COWICHAN R UP
025008	1987	26817	123720	21.7	7.49	1988/05/25	1988/05/26	COWICHAN R UP
024860	1988	25117	25243	99.5	3.66		1989/04/28	COWICHAN R
025012	1988	26595	54768	48.6	6.49		1989/05/21	COWICHAN R
025013	1988	25982	54154	48.0	6.49		1989/05/21	COWICHAN R
025015	1988	23058	24894	92.6	3.66		1989/04/28	COWICHAN R
025016	1988	26821	26821	100.0	3.66		1989/04/28	COWICHAN R
025017	1988	27611	28175	98.0	3.66		1989/04/28	COWICHAN R
025523	1988	27531	56123	49.1	6.49		1989/05/21	COWICHAN R
025524	1988	27205	55378	49.1	6.49		1989/05/21	COWICHAN R
025749	1988	26922	133331	20.2	6.06		1989/05/15	COWICHAN LK
025750	1988	27036	133446	20.3	6.06		1989/05/15	COWICHAN LK
025751	1988	23106	130107	17.8	6.06		1989/05/15	COWICHAN LK
025752	1988	26169	132842	19.7	6.06		1989/05/15	COWICHAN LK
020352	1989	28287	28573	99.0	3.4	1990/04/12	1990/04/12	COWICHAN R
020522	1989	27072	36800	73.6	6.53	1990/05/22	1990/05/23	COWICHAN R
020622	1989	27787	37242	74.6	6.53	1990/05/22	1990/05/23	COWICHAN R
020623	1989	28164	37619	74.9	6.53	1990/05/22	1990/05/23	COWICHAN R
020624	1989	28331	37786	75.0	6.53	1990/05/22	1990/05/23	COWICHAN R
020938	1989	28312	28312	100.0	3.4	1990/04/12	1990/04/12	COWICHAN R
020939	1989	26218	26218	100.0	3.4	1990/04/12	1990/04/12	COWICHAN R
026103	1989	27145	27145	100.0	3.4	1990/04/12	1990/04/12	COWICHAN R
026255	1989	26400	119674	22.1	7.19		1990/05/14	COWICHAN LK

Table 12. (continued)

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
026256	1989	25693	119497	21.5	7.19		1990/05/14	COWICHAN LK
026257	1989	25790	119325	21.6	7.19		1990/05/14	COWICHAN LK
026258	1989	25219	118748	21.2	7.19		1990/05/14	COWICHAN LK
020333	1990	25687	94172	27.3	8.43	1991/05/15	1991/05/15	COWICHAN LK
020334	1990	25898	94384	27.4	8.43	1991/05/15	1991/05/15	COWICHAN LK
020335	1990	25739	94224	27.3	8.43	1991/05/15	1991/05/15	COWICHAN LK
020336	1990	27135	27135	100.0	3.31	1991/04/17	1991/04/17	COWICHAN R
020337	1990	26631	26631	100.0	3.31	1991/04/17	1991/04/17	COWICHAN R
020338	1990	27046	27046	100.0	3.31	1991/04/17	1991/04/17	COWICHAN R
020339	1990	26721	34318	77.9	6.4	1991/05/21	1991/05/22	COWICHAN R
020340	1990	26993	34592	78.0	6.4	1991/05/21	1991/05/22	COWICHAN R
020341	1990	26533	33995	78.0	6.4	1991/05/21	1991/05/22	COWICHAN R
020342	1990	25437	92182	27.6	4.75	1991/06/17	1991/06/18	COWICHAN R
020343	1990	25391	92136	27.6	4.75	1991/06/17	1991/06/18	COWICHAN R
NOCN9044	1990		5086	0.0	5.41	1991/06/26	1991/06/26	COWICHAN ESTUARY
180513	1991	26972	336330	8.0	5.04	1992/05/17	1992/05/17	COWICHAN LK
180514	1991	25964	335584	7.7	5.04	1992/05/17	1992/05/17	COWICHAN LK
180515	1991	27694	254287	10.9	4.01	1992/04/21	1992/04/22	COWICHAN R LOW
180516	1991	27148	254015	10.7	4.01	1992/04/21	1992/04/22	COWICHAN R LOW
180517	1991	27471	505110	5.4	5.47	1992/05/19	1992/05/21	COWICHAN R UP
180518	1991	27277	504916	5.4	5.47	1992/05/19	1992/05/21	COWICHAN R UP
180519	1991	27432	160695	17.1	3.75	1992/04/21	1992/04/22	COWICHAN R LOW
180520	1991	27001	160262	16.8	3.75	1992/04/21	1992/04/22	COWICHAN R LOW
180521	1991	26871	27444	97.9	6.29	1992/05/29	1992/05/29	COWICHAN ESTUARY
180522	1991	26852	27424	97.9	6.29	1992/05/29	1992/05/29	COWICHAN ESTUARY
NOCN9145	1991		513053	0.0	5.69	1992/05/19	1992/05/20	COWICHAN R UP
180209	1992	24770	98974	25.0	6.3	1993/05/25	1993/05/25	COWICHAN ESTUARY
180210	1992	26383	327416	8.1	5.86	1993/05/17	1993/05/19	COWICHAN R UP
180550	1992	25311	326344	7.8	5.86	1993/05/17	1993/05/19	COWICHAN R UP
181042	1992	53620	412953	13.0	6.52	1993/05/25	1993/05/25	COWICHAN R
181043	1992	54235	901937	6.0	5.64	1993/05/10	1993/05/10	COWICHAN LK
181044	1992	55027	907719	6.1	3.56	1993/04/07	1993/04/07	COWICHAN R UP
021211	1993	24875	103900	23.9	6.17	1994/05/25	1994/05/25	COWICHAN BAY
181319	1993	49966	1001002	5.0	6.29	1994/05/05	1994/05/05	COWICHAN LK
181320	1993	50420	684279	7.4	3.79	1994/04/18	1994/04/18	COWICHAN R UP
181321	1993	50045	652354	7.7	6.11	1994/05/18	1994/05/18	COWICHAN R UP
181322	1993	50285	490079	10.3	6.06	1994/05/24	1994/05/24	COWICHAN R
181329	1994	25023	103815	24.1	6.08	1995/05/31	1995/05/31	COWICHAN BAY
181436	1994	50133	100252	50.0	5.44	1995/05/30	1995/05/30	COWICHAN R
181437	1994	49962	418750	11.9	4	1995/05/02	1995/05/02	COWICHAN R UP
181438	1994	49610	939287	5.3	6.32	1995/05/15	1995/05/17	COWICHAN R UP
181439	1994	49846	101763	49.0	6.48	1995/05/25	1995/05/25	COWICHAN LK
182023	1995	25114	109088	23.0	6.76	1996/05/10	1996/05/10	COWICHAN BAY
182024	1995	25653	297360	8.6	6.56	1996/05/06	1996/05/06	COWICHAN LK
182025	1995	24488	283856	8.6	6.56	1996/05/06	1996/05/06	COWICHAN LK
182026	1995	25183	355089	7.1	6.26	1996/05/07	1996/05/07	COWICHAN R UP
182027	1995	25218	355583	7.1	6.26	1996/05/07	1996/05/07	COWICHAN R UP

Table 12. (continued)

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
182028	1995	25052	344597	7.3	3.47	1996/04/02	1996/04/02	COWICHAN R UP
182029	1995	25129	345657	7.3	3.47	1996/04/02	1996/04/02	COWICHAN R UP
182030	1995	25196	245910	10.2	6.37	1996/05/09	1996/05/09	COWICHAN R
182031	1995	25020	244193	10.2	6.37	1996/05/09	1996/05/09	COWICHAN R
182737	1996	25235	100196	25.2	6.79	1997/05/07	1997/05/07	COWICHAN BAY
182738	1996	25108	318583	7.9	5.44	1997/04/30	1997/04/30	COWICHAN LK
182739	1996	25205	319814	7.9	5.44	1997/04/30	1997/04/30	COWICHAN LK
182740	1996	25218	448340	5.6	6.29	1997/04/28	1997/04/29	COWICHAN R UP
182741	1996	25649	456002	5.6	6.29	1997/04/28	1997/04/29	COWICHAN R UP
182742	1996	25457	401644	6.3	3.34	1997/04/01	1997/04/01	COWICHAN R UP
182743	1996	25019	394733	6.3	3.34	1997/04/01	1997/04/01	COWICHAN R UP
182744	1996	25154	219780	11.4	5.89	1997/05/05	1997/05/05	COWICHAN R
182745	1996	25082	219151	11.4	5.89	1997/05/05	1997/05/05	COWICHAN R
182761	1997	25213	25213	100.0	3.68	1998/04/09	1998/04/09	COWICHAN R UP
182762	1997	25206	25206	100.0	3.68	1998/04/09	1998/04/09	COWICHAN R UP
182763	1997	25698	25698	100.0	3.68	1998/04/09	1998/04/09	COWICHAN R UP
182801	1997	24817	28209	88.0	6.47	1998/05/13	1998/05/13	COWICHAN R UP
182802	1997	24890	28282	88.0	6.47	1998/05/13	1998/05/13	COWICHAN R UP
182803	1997	24923	28316	88.0	6.47	1998/05/13	1998/05/13	COWICHAN R UP
182804	1997	24971	24971	100.0	6.46	1998/05/21	1998/05/21	COWICHAN R
182805	1997	25026	25026	100.0	6.46	1998/05/21	1998/05/21	COWICHAN R
183213	1997	24915	51754	48.1	6.27	1998/05/25	1998/05/25	COWICHAN BAY
183107	1998	25163	224868	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183108	1998	25201	225208	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183109	1998	24803	132012	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183110	1998	24927	132676	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183111	1998	25163	75629	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183112	1998	24875	74763	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183726	1998	25135	356567	7.0	5.93	1999/05/07	1999/05/07	COWICHAN LK
183727	1998	25136	356568	7.0	5.93	1999/05/07	1999/05/07	COWICHAN LK
183728	1998	25234	225504	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183729	1998	25087	224189	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183730	1998	24867	132354	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183731	1998	24921	132644	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183732	1998	24959	75015	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183733	1998	25024	75211	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183734	1998	25127	99928	25.1	5.1	1999/05/17	1999/05/17	COWICHAN BAY
183119	1999	24855	270757	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183120	1999	24917	271436	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183121	1999	24933	271609	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183122	1999	25024	272601	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183123	1999	24776	481197	5.1	6.58	2000/04/27	2000/04/28	COWICHAN R UP
183124	1999	24839	482428	5.1	6.58	2000/04/27	2000/04/28	COWICHAN R UP
183125	1999	25118	215385	11.7	6.99	2000/05/05	2000/05/05	COWICHAN R
183126	1999	25039	215306	11.6	6.99	2000/05/05	2000/05/05	COWICHAN R
183127	1999	25078	99936	25.1	8.66	2000/05/17	2000/05/17	COWICHAN BAY
182811	2000	25175	99829	25.2	7.98	2001/05/23	2001/05/23	COWICHAN BAY
183216	2000	25152	504558	5.0	6.55	2001/05/01	2001/05/01	COWICHAN R UP

Table 12. (continued)

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
183217	2000	24833	503194	4.9	6.55	2001/05/01	2001/05/01	COWICHAN R UP
184539	2000	50166	338640	14.8	6.21	2001/05/03	2001/05/03	COWICHAN R
184546	2000	49972	481337	10.4	3.19	2001/03/19	2001/03/20	COWICHAN R UP
184547	2000	50054	482162	10.4	3.19	2001/03/19	2001/03/20	COWICHAN R UP
184448	2001	25163	96786	26.00	5.68	2002/05/21	2002/05/21	COWICHAN BAY
184639	2001	25140	249911	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184640	2001	25047	248987	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184641	2001	25255	251054	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184642	2001	24957	248092	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184643	2001	25068	787409	3.18	5.68	2002/05/14	2002/05/15	COWICHAN R UP
184644	2001	25062	787221	3.18	5.68	2002/05/14	2002/05/15	COWICHAN R UP
184645	2001	25019	278423	8.99	5.28	2002/04/28	2002/04/28	COWICHAN R
184646	2001	25197	280404	8.99	5.28	2002/04/28	2002/04/28	COWICHAN R

[1] Cowichan River Hatchery release strategies for chinook:

Upper Cowichan River (late): raised to pre-smolt size (5-6 g) prior to release approximately 3 km below the weir in May.

Upper Cowichan River (early): raised to fry (3 g) prior to release approximately 3 km below the weir in early April.

Cowichan Lake Pen: raised to pre-smolt size (5-6 g) prior to release just above the weir in May.

Hatchery (late): raised to pre-smolt size (5-6 g) prior to release at the hatchery in May.

Seapen: raised to smolt size (6+ g) prior to release from the netpens in Cowichan Bay in early June.

Table 13. Daily Cowichan River discharge[1] (m^3/s) during 2002 [2].

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	82.3	76.4	87.7	53.1	45.1	31.9	12.3	5.7	5.6	6.0	5.6	74.5
2	109.9	72.8	82.4	51.0	46.4	30.4	11.5	5.5	5.4	6.6	5.4	69.3
3	137.2	73.2	77.9	45.8	46.3	29.2	10.8	6.0	5.6	12.7	5.3	64.1
4	133.8	72.8	73.6	42.4	43.3	27.7	10.5	6.2	5.9	14.7	5.1	59.6
5	127.8	73.1	70.4	38.0	41.9	27.4	10.0	6.2	5.8	14.1	5.0	55.4
6	147.4	79.7	67.1	36.8	39.6	27.5	9.2	6.1	5.8	13.0	5.3	51.5
7	274.5	90.2	64.1	35.5	36.2	26.0	8.6	5.9	6.0	12.0	6.0	48.1
8	288.6	86.8	60.3	33.5	33.8	23.9	9.2	5.7	6.0	9.9	6.5	45.5
9	250.2	80.1	58.1	34.3	31.9	22.2	8.8	5.7	5.9	6.4	7.5	42.7
10	226.7	76.6	57.8	36.3	30.6	21.1	8.0	6.0	6.3	6.1	7.2	42.6
11	206.9	74.3	81.8	37.1	29.4	19.8	7.9	5.9	6.8	5.9	11.1	45.9
12	193.5	71.3	96.6	43.6	26.7	18.7	7.5	5.8	6.4	5.8	20.4	78.7
13	178.3	67.8	99.7	62.6	27.2	17.6	6.9	5.8	6.2	6.2	23.8	99.6
14	161.8	65.2	88.3	102.6	28.4	17.9	6.9	6.1	5.9	6.0	28.7	143.8
15	147.5	62.0	81.8	103.5	27.8	17.3	6.6	5.9	5.9	5.9	47.9	154.0
16	135.5	60.4	78.0	100.8	26.8	15.8	6.3	5.8	6.3	5.8	66.5	153.4
17	129.1	59.3	73.5	99.4	27.4	15.6	6.0	5.8	6.3	5.8	79.5	141.1
18	121.0	57.8	70.0	93.2	26.9	16.8	6.0	6.1	6.1	5.8	113.3	131.5
19	111.0	63.8	67.5	88.0	26.4	15.9	6.1	6.1	6.5	5.7	167.4	125.2
20	106.7	69.0	65.1	82.5	26.4	14.4	5.9	6.0	6.2	5.6	178.7	117.3
21	100.4	117.9	61.9	77.6	26.4	13.5	5.7	5.9	6.2	6.0	162.9	105.8
22	94.6	174.0	59.5	72.9	26.0	13.0	5.5	5.8	5.9	5.9	150.6	99.6
23	89.6	148.4	57.7	68.2	24.6	12.5	5.5	5.7	5.8	5.9	141.6	93.5
24	98.2	128.8	56.7	63.2	23.5	11.5	5.6	5.7	5.6	6.2	129.8	87.1
25	114.3	114.5	56.1	58.8	23.3	10.5	5.7	5.8	5.5	5.9	116.5	148.0
26	103.9	106.8	55.1	55.3	23.6	10.3	5.7	6.0	5.8	5.7	108.1	162.9
27	96.7	100.3	54.5	52.2	24.1	10.0	5.9	5.7	5.8	5.8	99.3	122.8
28	89.5	93.3	54.0	49.8	26.0	10.3	5.8	5.6	5.7	5.9	92.3	110.3
29	85.7		54.7	44.9	31.8	12.6	5.7	5.6	5.8	5.8	86.1	97.7
30	82.1		53.5	43.3	34.3	12.9	5.7	5.4	6.1	5.5	79.5	96.9
31	79.2		53.1		33.4		5.8	5.6		5.6		91.9
Total	4304	2416	2119	1806	965.4	553.9	227.4	181.1	179	224.1	1963	2960
Mean	138.8	86.3	68.3	60.2	31.1	18.5	7.3	5.8	6.0	7.2	65.4	95.5
Max	288.6	174	99.69	103.5	46.38	31.89	12.3	6.214	6.769	14.73	178.7	162.9
Min	79.24	57.84	53.07	33.53	23.28	9.957	5.477	5.437	5.445	5.498	4.984	42.6

[1] Water Survey of Canada data recorded at the Island Highway bridge in Duncan, BC.

[2] Discharge data are preliminary and subject to revision.

Table 14a. Daily summary of carcasses examined, tags applied and tagged recoveries, by sex, for chinook in the Cowichan River, 2002.

	Carcasses Examined				Tags Applied				Tagged Carcasses Recovered			
Date	Unkn.	Male	Female	Jack	Unkn.	Male	Female	Jack	Unkn.	Male	Female	Jack
04-Nov	0	2	12	5	0	2	12	5	0	0	0	0
05-Nov	0	14	9	20	0	14	9	20	0	0	0	0
06-Nov	0	15	6	19	0	15	6	18	0	0	0	1
07-Nov	0	6	10	5	0	5	10	5	0	1	0	0
08-Nov	0	4	12	15	0	4	12	15	0	0	0	0
12-Nov	0	6	5	6	0	4	4	5	0	2	1	1
14-Nov	0	1	1	1	0	1	1	1	0	0	0	0
15-Nov	0	5	12	17	0	5	8	12	0	0	4	5
18-Nov	0	2	7	2	0	2	7	2	0	0	0	0
19-Nov	0	3	8	1	0	2	6	0	0	1	2	1
20-Nov	0	3	5	2	0	3	2	2	0	0	3	0
21-Nov	0	0	3	2	0	0	2	2	0	0	1	0
22-Nov	0	0	0	3	0	0	0	3	0	0	0	0
25-Nov	0	2	3	4	0	0	3	4	0	2	0	0
26-Nov	0	3	2	4	0	2	2	4	0	1	0	0
27-Nov	0	0	3	5	0	0	3	2	0	0	0	3
28-Nov	0	1	3	2	0	1	2	2	0	0	1	0
29-Nov	0	0	3	0	0	0	2	0	0	0	1	0
Total	0	67	104	113	0	60	91	102	0	7	13	11

Table 14b. Tags applied, carcasses examined and marks recovered, by sex, for chinook in the Cowichan River, 2002.

Sex	Tags Applied	Carcasses Examined	Marks Recovered	Percent Recovered
Male	60	67	7	11.7%
Female	91	104	13	14.3%
Jack	102	113	11	10.8%

Table 15. Petersen mark-recapture estimates, stratified by sex, for Cowichan River chinook, 2002.

Sex	Population Estimate	95% Confidence Limits	
		Lower	Upper
Male	519	200	837
Female	690	364	1016
Total Adult	**1245**	**757**	**1733**
Jack	979	475	1482
Total Population	2262	1534	2990

Table 16. Incidence of tagged adult chinook carcasses recovered on the spawning grounds by recovery period and sex, Cowichan River, 2002.

Recovery Period	Days of Recovery	Tagged Recoveries			Total Recoveries			Tag Incidence (%)		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Nov 04 - Nov 10	7	1	0	1	41	49	90	2.44	0.00	1.11
Nov 11 - Nov 17	7	2	5	7	12	18	30	16.67	27.78	23.33
Nov 18 - Nov 23	6	1	6	7	8	23	31	12.50	26.09	22.58
Nov 24 - Nov 29	6	3	2	5	6	14	20	50.00	14.29	25.00
Total	26	7	13	20	67	104	171	10.45	12.50	11.70
Chi-Square Test Result:								13.38	14.76	
Critical Chi-Square (df = 3; p<0.01)								11.35	11.35	

Table 17. Proportion of the tag application sample recovered on the spawning grounds by application period and sex, Cowichan River, 2002.

Application Period	Days of Application	Tags Applied			Tagged Recoveries			Percent Recovered		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Nov 04 - Nov 10	7	40	49	89	1	0	1	2.50	0.00	1.12
Nov 11 - Nov 17	7	10	13	23	2	5	7	20.00	38.46	30.43
Nov 18 - Nov 23	6	7	17	24	1	6	7	14.29	35.29	29.17
Nov 24 - Nov 29	6	3	12	15	3	2	5	100.00	16.67	33.33
Total		60	91	151	7	13	20	11.67	14.29	13.25
Chi-Square test result:								26.70	20.55	
Critical Chi-Square (df = 3; p<0.01)								11.35	11.35	

Table 18. Sex composition of chinook in the tag application and recovery samples from the Cowichan River spawning grounds, 2002.

	Application sample by recovery status				Recovery sample by mark status			
Sex	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	60	35.0%	40.5%	39.7%	67	35.0%	39.7%	39.2%
Female	91	65.0%	59.5%	60.3%	104	65.0%	60.3%	60.8%
Chi-Square test result:				0.22				0.17
Critical Chi-Square (df = 1; p<0.01)				6.64				6.64

Table 19. Sex composition of chinook in the tag application and recovery samples from the Cowichan River spawning grounds, 2002 (jacks included).

	Application sample by recovery status				Recovery sample by mark status			
Sex	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	60	22.6%	23.9%	23.7%	67	22.6%	23.7%	23.6%
Female	91	41.9%	35.1%	36.0%	104	41.9%	36.0%	36.6%
Jack	102	35.5%	41.0%	40.3%	113	35.5%	40.3%	39.8%
Chi-Square test result:				0.57				0.45
Critical Chi-Square (df = 2; p<0.01)				9.21				9.21

Table 20. Total adult chinook returns to the Cowichan River for the years 1975-2002.

Year	Natural Spawners	Broodstock Removal	First Nations Catch	Total Return
1975	6500		900	7400
1976	3460		1000	4460
1977	4150		1000	5150
1978	4370		500	4870
1979	8750	195	500	9445
1980	5950	337	1500	7787
1981	5500	282	1500	7282
1982	4500	534	1000	6034
1983	4500	242	250	4992
1984	5000	278	355	5633
1985	3500	175	1000	4675
1986	1832	315	800	2947
1987	1937	582	800	3319
1988	6200	678	681	7559
1989	5000 [1]	535 [2]	1055	6590
1990	5300	326	820	6446
1991	6000 [3]	1755	250	8005
1992	8500	1850	260	10610
1993	5058	1970	295	7323
1994	5050	1357	345	6752
1995	14300	2149	533	16982
1996	12980	1615	810	15405
1997	9845	125	191	10161
1998	4371	1485	1073	6929
1999	4500	1659	233	6692 [4]
2000	5109 [5]	1529	89	7027 [4]
2001	3282 [5]	1732	918	6232 [4]
2002	2505 [5]	1480	1500	5785 [4]

[1] For the years 1989 to the present, the number of natural spawners was calculated as the number of adults recorded at the fence minus the adults removed for broodstock above the fence. In years when fence counts were incomplete, the cumulative run timing curve was used to expand the count.

[2] This number is the total broodstock removed and may include some jacks.

[3] Due to early flooding, estimate is based on expansion of swim surveys and weir counts.

[4] Includes an estimated 300 chinook lost to seal predation in the Cowichan estuary.

[5] For the years 2000 to the present, the adult fence count totals used in calculating natural spawners was adjusted using jack/adult ratios obtained from the spawning grounds.

Figure 1. Cowichan River survey areas.

Swim survey locations were:

1 - Bird House Pool
2 - Road Pool
3 - Train Trestle (mile 70.2)
4 - Old Pick-up Site
5 - Maple Tree
6 - Three Firs Pool
7 - Skutz Falls
8 - Marie Canyon
9 - Bible Camp
10 - Cowichan Side channel
11 – Sandy Pool
12 – Sewer
13 – J.C. Pool

Swim survey areas:

Bird House (1) to Three Firs Pool (6) represents the upper survey section.

Marie Canyon (8) to enumeration fence (A) represents the middle survey section.

A - Refers to the adult enumeration fence

Tag recovery locations:

Locations numbered 1 to 45 are in the upper river section, those numbered 46 to 83 are in the middle river section.

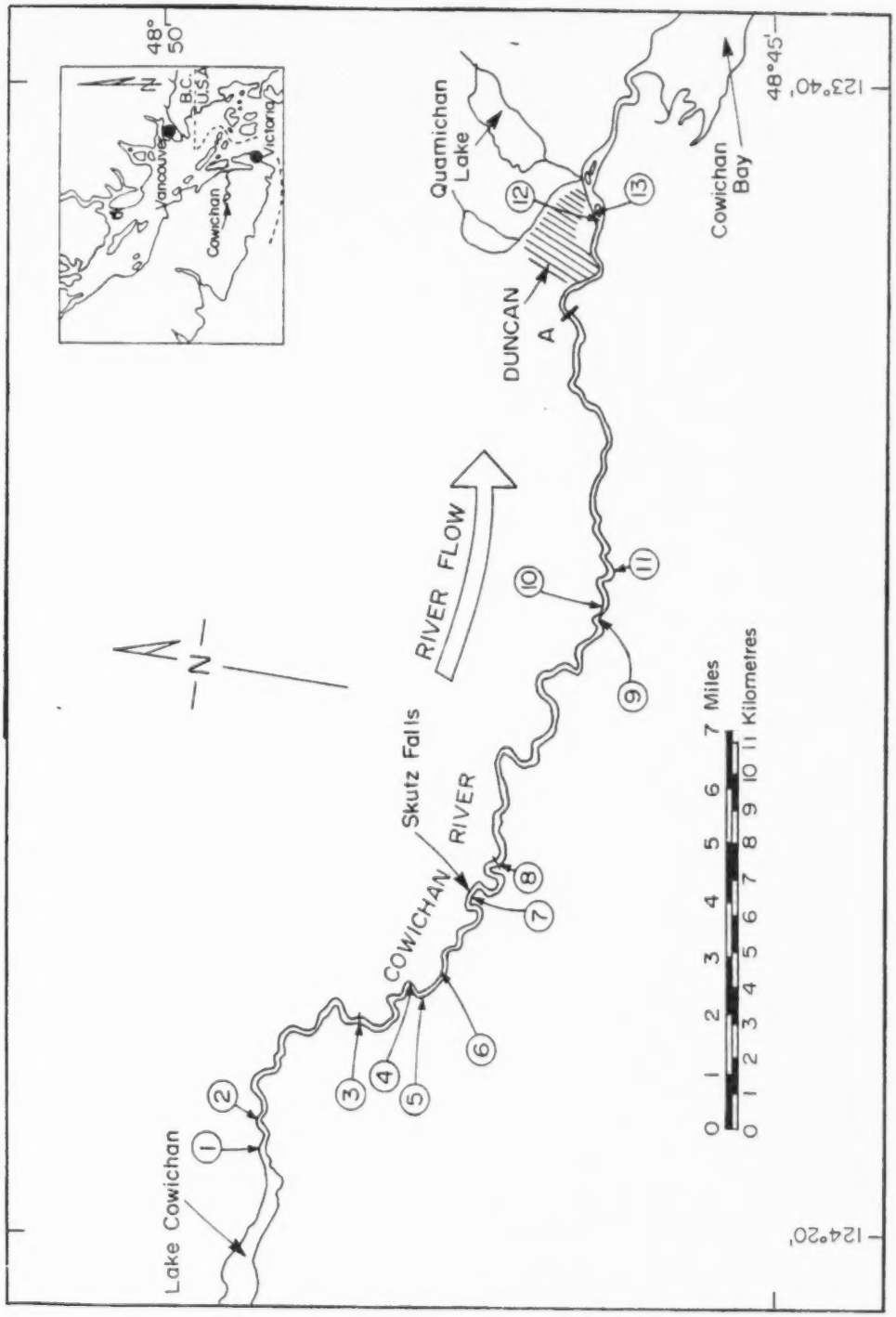

48° 50'
N
B.C.
U.S.A.
Vancouver
Victoria
Cowichan
Quamichan Lake
Cowichan Bay
DUNCAN
A
123°40'
48°45'
124°20'
RIVER FLOW
N
Skutz Falls
RIVER
COWICHAN
Lake Cowichan
1
2
3
4
5
6
7
8
9
10
11
12
13
0 1 2 3 4 5 6 7 Miles
0 1 2 3 4 5 6 7 8 9 10 11 Kilometres

Figure 2. River management zones for the First Nations food fishery.

A-Cliffs to Silver Bridge

B-Silver Bridge to J.C.'s Place

C-Quamichan to Black Creek

D-Powerline to Elliot's Barn

E-Elliot's Barn to Brian's Pool

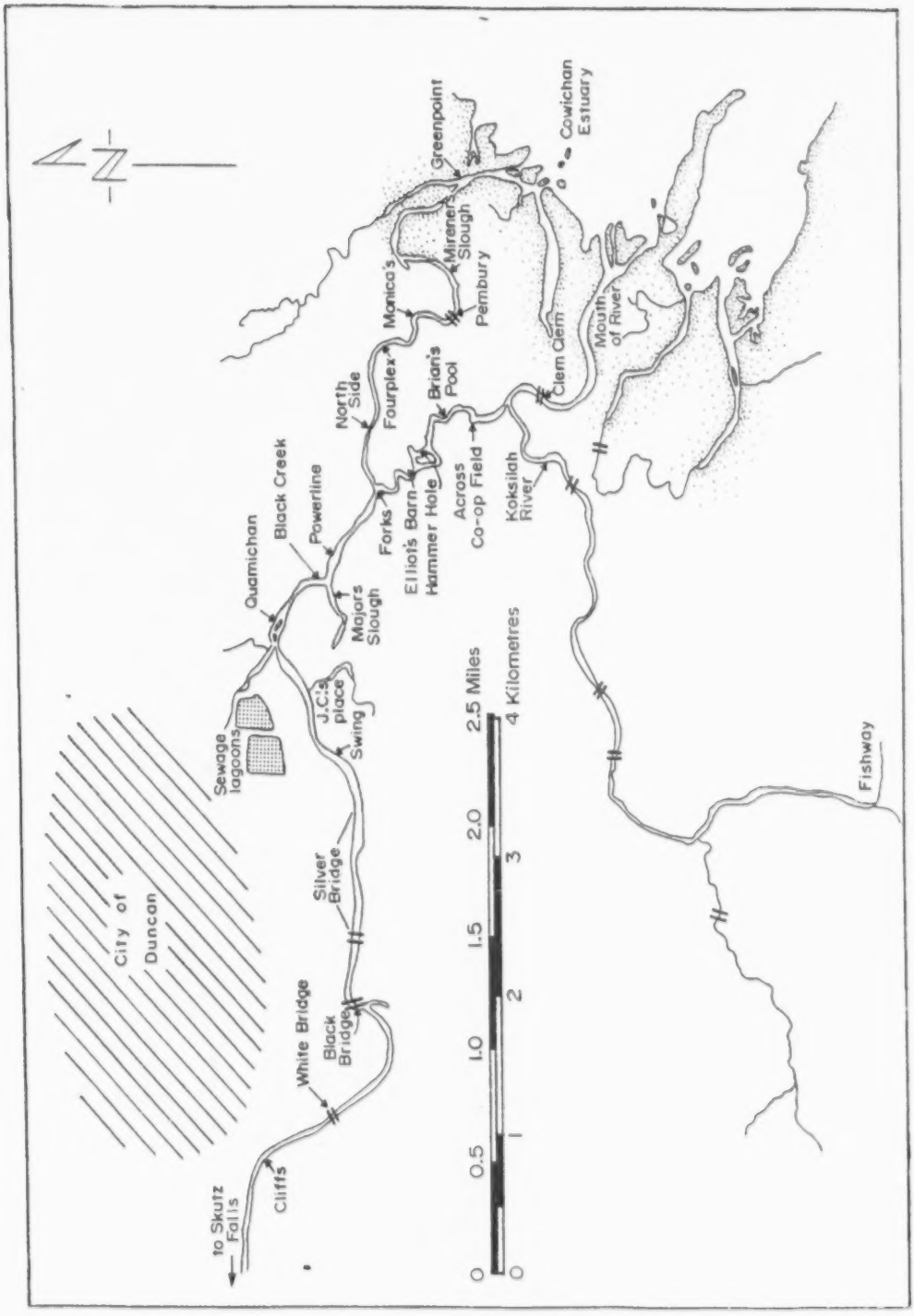
F-Brian's Pool to Clem Clem and part of Koksilah

G-Clem Clem to Mouth of River

H-North Side to Fourplex

I-Fourplex to Meriner's Slough

J-Meriner's Slough to Mouth of River


N
Greenpoint
Cowichan Estuary
Mirener Slough
Pembury
Monica's
Mouth of River
Clem Clem
Fourplex
North Side
Brian's Pool
Powerline
Black Creek
Quamichan
Forks
Elliot's Barn
Hammer Hole
Across Co-op Field
Koksilah River
Majors Slough
J.C.'s place
Swing
Sewage lagoons
Silver Bridge
City of Duncan
White Bridge
Black Bridge
Cliffs
to Skutz Falls
Fishway
0
0.5
1.0
1.5
2.0
2.5 Miles
0
1
2
3
4 Kilometres

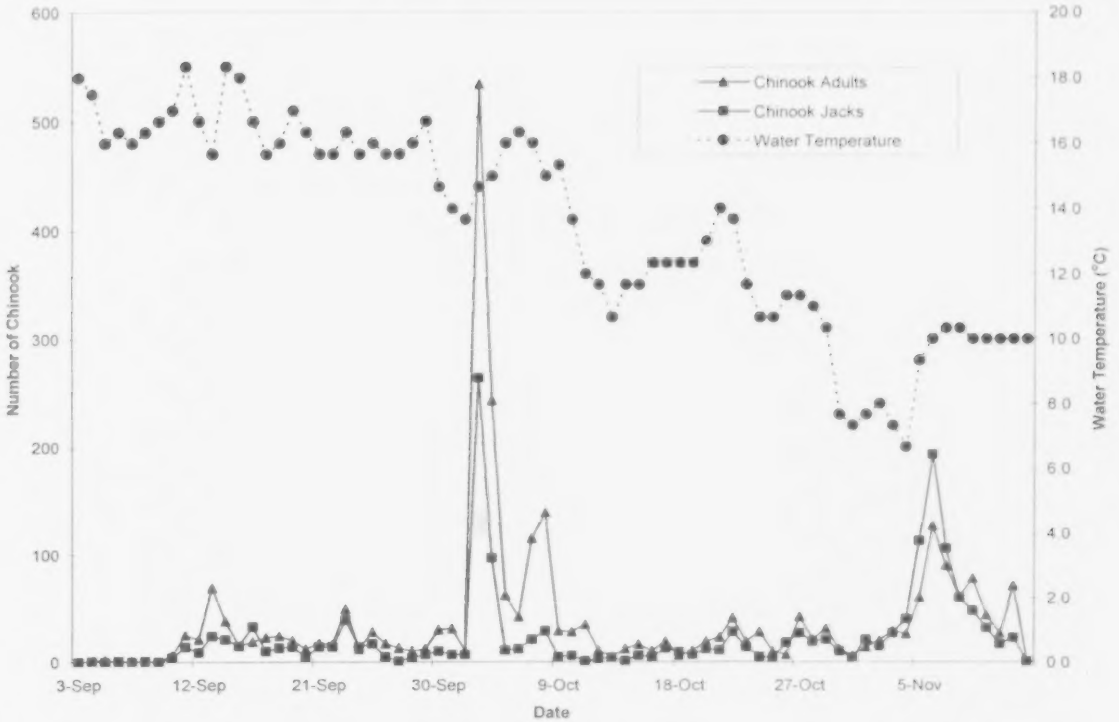


Figure 3a. Daily fence counts of adult and jack chinook and water temperature at the fence site, Cowichan River, 2002.

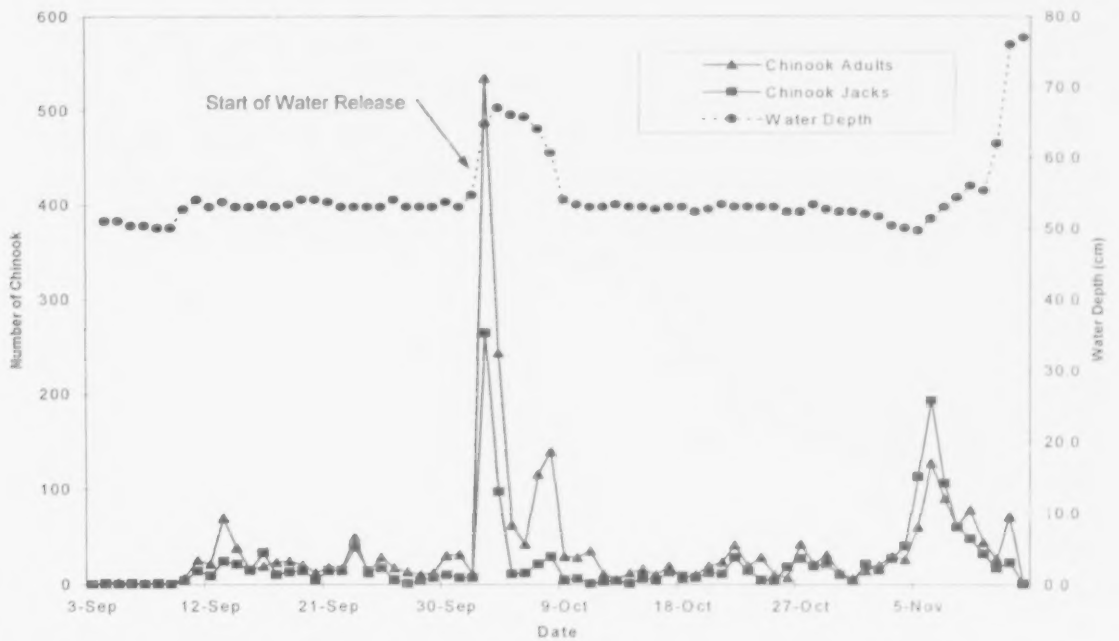


Figure 3b. Daily fence counts of adult and jack chinook and water depth at the fence site, Cowichan River, 2002.

Figure 4. Adult chinook catch from the First Nations food fishery, Cowichan River, 1971-2002.

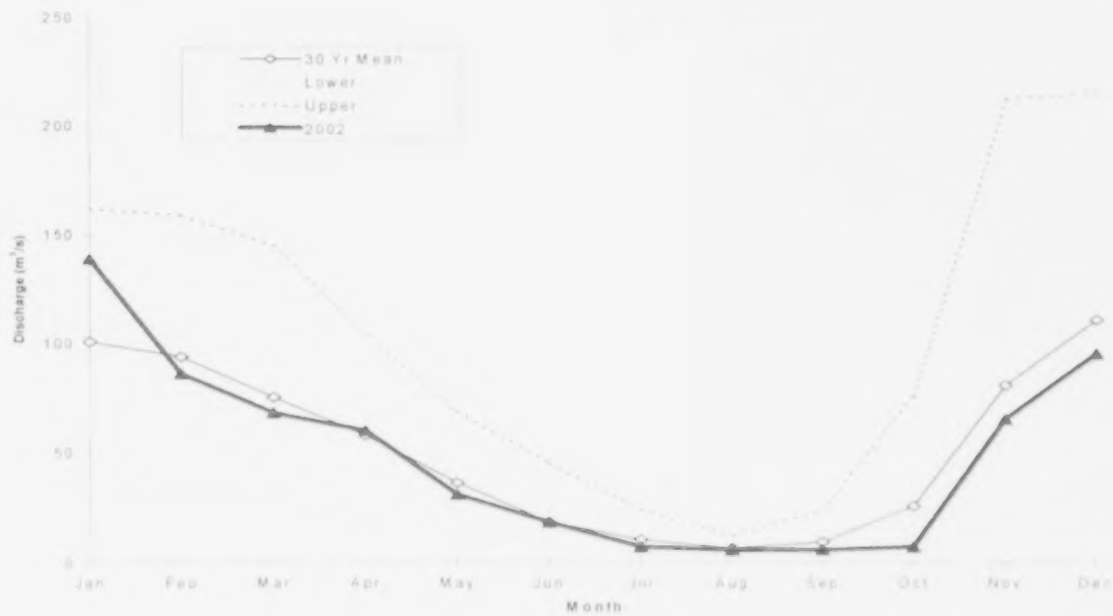


Figure 5. Monthly Cowichan River discharge (m^3/s) in 2002 along with historical values.

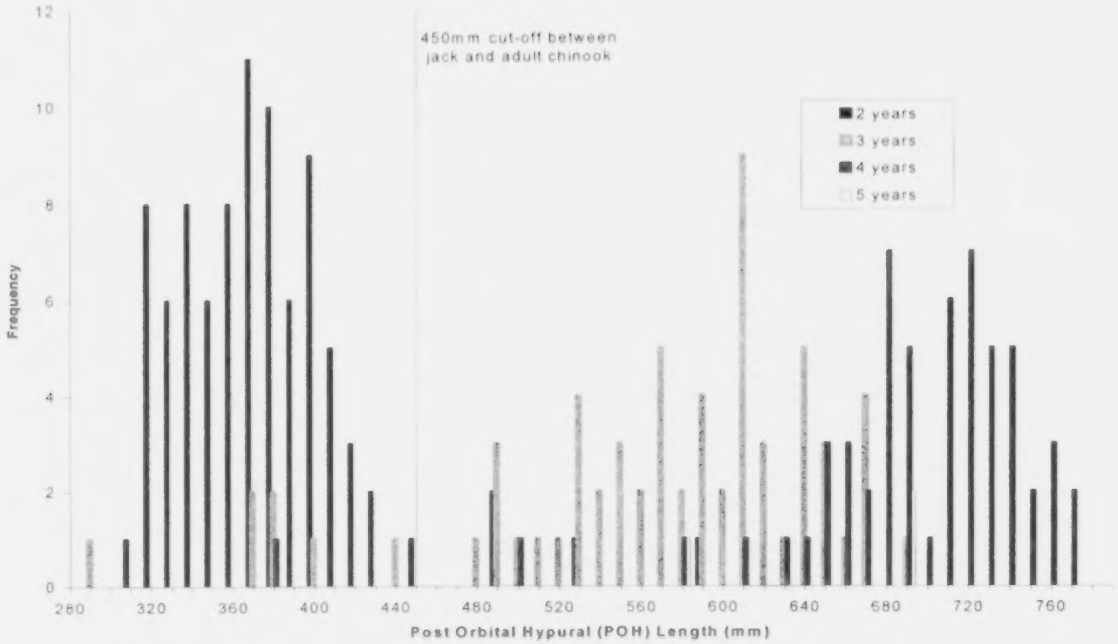


Figure 6. Adult and jack chinook length-frequencies collected from the Cowichan River spawning grounds, 2002.

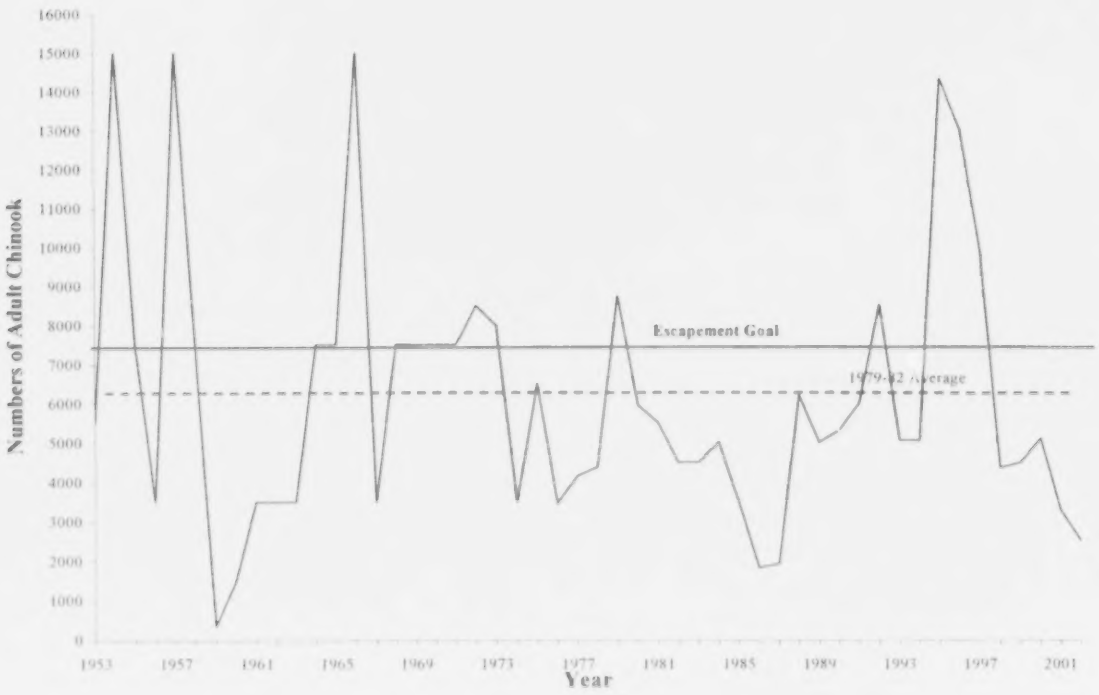


Figure 7. Annual adult chinook escapement estimates for the Cowichan River, 1953-2002.

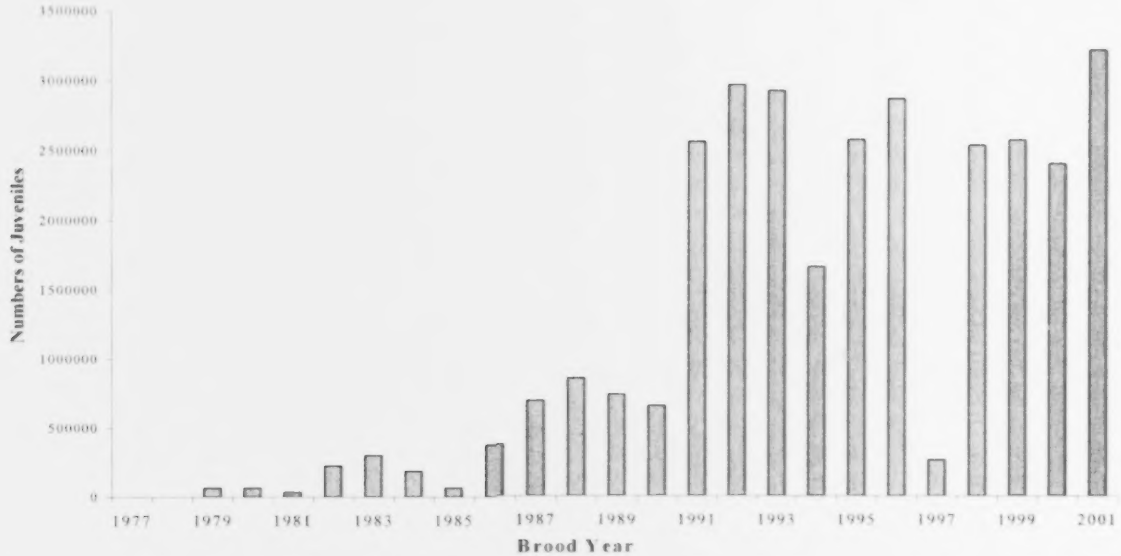


Figure 8. Annual releases of hatchery chinook into the Cowichan River as fry (3 g) and as pre-smolts (6 g).

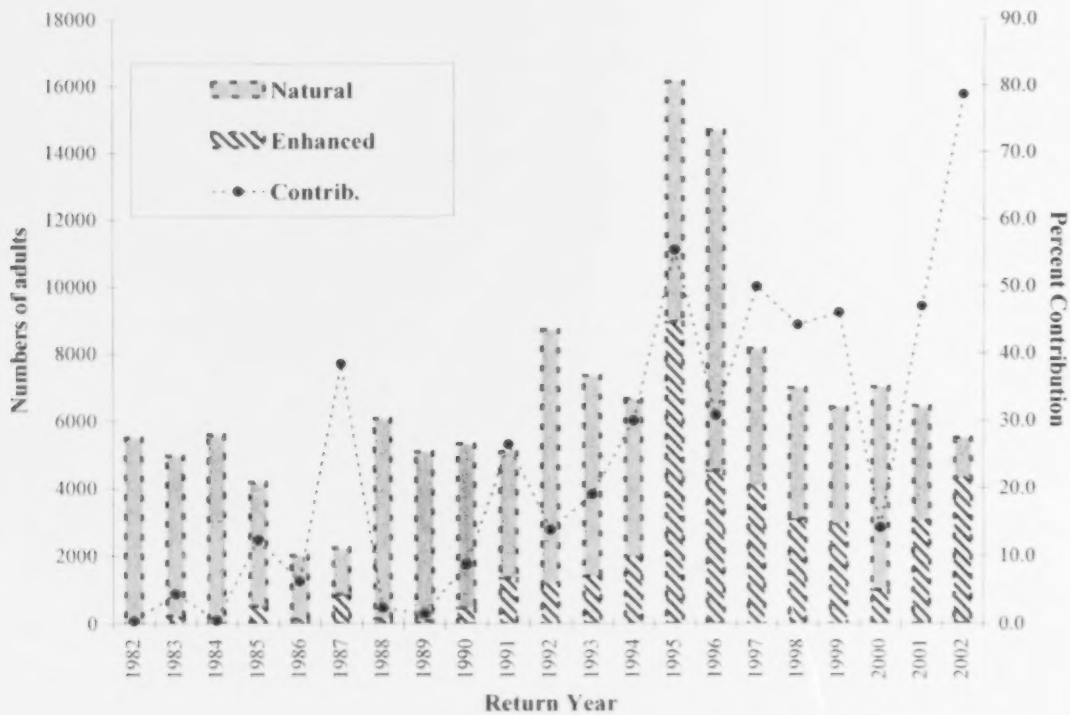


Figure 9. Annual natural and enhanced contributions to adult chinook escapement, Cowichan River, 1982-2002.